Chapter 9.—PERIODS OF THE GROUND IN SOUTHERN CALIFORNIA EARTHQUAKES

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HISTORY

From the early seismic records various Japanese scientists found that the microseisms which are produced by traffic, industry, and meteorological conditions, as storms and surf, show certain prevailing periods which are different in different localities. Omori and Kikuchi [1] have especially investigated this problem. Kikuchi expressed his opinion that the prevailing periods constituted the free periods of the ground and their harmonics. The problem of the connection between periods of microseisms produced by local causes and the free periods of the ground has been investigated frequently since. O. Geussenhainer [2] in his investigation of microseisms in Göttingen with periods between 5 and 9 seconds found that they change gradually in the course of time in the vertical component, but that in the horizontal component periods of 6, 7.5, and 9 seconds prevail. He believed these periods to be free periods of Love waves in the ground near Göttingen or harmonics of such.

One of the first who investigated the connection between periods in earthquakes and free periods of the ground was A. Imamura.[3] He found that seismograms may involve, beside seismic waves propagated from the focus to a given station, vibrations induced at the station. From an examination of the seismograms due to the same earthquake and obtained at various seismological stations in the Kwanto district, he found for the induced earth vibrations the following periods:

	Seconds
Station on soil	0. 2–0. 3
Station on alluvium	0. 4–0. 5
Station on tertiary	0. 6–0. 7

The results of Imamura caused K. Sezawa, G. Nishimura, and K. Kanai [4] to investigate thoroughly the possibility of free oscillations of the ground excited by seismic waves.

The importance of such investigations concerning the engineering problems in erecting buildings was recognized relatively early. There are many publications in which the idea has been stressed that in

[1] F. Omori, Observations of Earthquakes at Hitotsubashi, 1900 (Publications of the Earthquake Investigation Committee in foreign languages, 13. 1903).
F. Omori, Tilting of the Ground During a Storm (Bulletin of the Imperial Earthquake Investigation Committee, I, Tokyo, 1907).
Baron Dairoku Kikuchi, Recent Seismological Investigations (Publications of the Earthquake Investigation Committee in foreign languages, 19, Tokyo, 1904).

[2] O. Geussenhainer, Ein Beitrag zum Studium der Bodenunruhe . . . ; Diss. Göttingen 1921, Auszug im Jahrb. d. philos. Fakultät *Göttingen* 1921, Nr. 18, Geophysik, p. 73.

[3] A. Imamura, Earth Vibrations Induced in Some Localities at the Arrival of Seismic Waves (Bulletin of the Earthquake Research Institute, Tokyo, vol. VII, 1929, p. 493).

[4] K. Sezawa, Possiblity of the Free Oscillations of the Surface Layer Excited by the Seismic Waves (Bulletin of the Earthquake Research Institute, Tokyo, vol. VIII, 1930, p. 1).
K. Sezawa and G. Nishimura, Dispersion of a Shock in Echoing and Dispersive Elastic Bodies (Bulletin of the Earthquake Research Institute, Tokyo, vol. VIII, 1930, p. 321.)
K. Sezawa and K. Kanai, Possibility of the Free Oscillation of the Surface Layer Excited by the Seismic Waves, Part III.(Bulletin of the Earthquake Research Institute, Tokyo, vol. X, 1932, p. 1).

earthquake regions buildings should not have the same free periods as the ground. The high value of investigations concerning free periods of the ground has been clearly recognized by many scientists. For example, K. Suyehiro [5] wrote that the periods of earthquake motions play an important role in the destructive effect of an earthquake on buildings and other structures, and that it is important, therefore, to investigate the periods of habitual motion peculiar to the ground if such motion does really exist at ordinary times and during earthquakes. When we remember that the ground is made up of several strata, it is not difficult to understand the existence of a period of motion peculiar to a given district. For detecting the prevailing periods of earthquakes in a particular locality Suyehiro has devised and used a seismic vibration analyzer.[6] It consists of a number of compound pendulums having different natural periods, the shortest being 0.2 second and the longest 1.8 seconds, which are arranged side by side in a row along the side of a recording drum. With this instrument Suyehiro found that Hongo on the high ground of Tokyo has a habitual motion with a period of about 0.3 second both at ordinary times and during earthquakes. At Marunouchi, on the low ground of Tokyo, the analyzer indicated that the prevailing periods in earthquakes are generally 0.7 to 0.9 second, but that secondary and tertiary free motions of this district with smaller periods may be excited by minor but sharp earthquakes.

Detailed investigations on the periods prevailing in the neighborhood of Tokyo have been published by M. Ishimoto.[7] He gives periods recorded during the maximum phase of four earthquakes at nine different stations. In most cases the periods observed most frequently are between 0.3 and 0.5 second, but there is some difference between the prevailing periods due to the source as well as to the stations. For example, in the third earthquake investigated by him periods of 0.2 second prevail at practically all the stations. On the other hand at a few stations there are maxima in the neighborhood of 0.7 second.

Other investigations concerning the periods observed during earthquakes at Marunouchi (downtown in Tokyo) have been carried out by T. Saito and M. Suzuki.[8] They have found there that in the alluvial layer there are numerous waves having periods of about 0.2 and 0.7 second and in diluvial formations 0.25 second and 0.45 second. They tried to show that 0.25 second and 0.75 second are the free periods of the alluvial layer.

Thorough investigations concerning free periods of the ground have been carried out by Dr. R. Köhler.[9] He measured the periods during different phases in earthquake records and compared them with periods produced by vibrations of a large engine which was run with different frequencies. The records of the movements of the ground taken during these experiments showed clearly an increase in

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[5] K. Suyehiro, Engineering Seismology, Notes on American Lectures (Proceedings of the American Society of Civil Engineers, vol. 58, no. 4, 1932, p 9).

[6] K. Suyehiro, A Seismic Vibration Analyzer and the Records Obtained Therewith (Bulletin of the Earthquake Research Institute, Tokyo, vol. I, 1926, p. 59).

[7] M. Ishimoto, Observations accélérometriques des secousses sismiques dans les villes de Tokyo et Yokohama (premier rapport) (Bulletin of the Earthquake Research Institute, Tokyo, vol. XII, 1934, p. 234).

[8] T. Saito and M. Suzuki, On the Upper Surface and Undergound Seismic Disturbances at the Downtown in Tokyo (Bulletin of the Earthquake Research Institute, Tokyo, vol. XII, 1934, p. 517).

[9] R. Köhler, Eigenschwingungen des Undergrundes, ihre Anregung und ihre seismische Bedeutung (Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Math.-Phys. Klasse, Fachgruppe II, Neue Folge, Bd. 1, Nr. 2, 1934, p. 11).

amplitude when the engine was running with a certain period and decrease in amplitudes as soon as the period was either increased or decreased. Thus he found that the free periods of the ground corresponding to the maximum amplitudes in these records were between 0.30 and 0.35 second in the valley of the Leine near Göttingen. The same periods prevail in the records of earthquakes recorded at the Seismic Observatory of Göttingen from distances less than 300 kilometers. This result makes it very probable that the frequencies prevailing in earthquake records are largely influenced by the free vibrations of the ground at the station. Sinusoidal waves of quarry blasts recorded in Göttingen show only periods of 0.3 to 0.4 second.

At distances over 300 kilometers longer periods are recorded in the transverse waves and during the maxima of earthquake waves, while in the P-phase of earthquakes recorded in Göttingen the periods of 0.3 to 0.4 second prevail up to distances of about 1,000 kilometers; for all phases at distances over 1,000 kilometers periods of 1.2 seconds are more prevalent. Even at very great distances such periods are not infrequent there. Dr. Köhler, therefore, believes in the possibility that the period of 1.2 seconds is the period of the free vibration of the uppermost crustal layer at Göttingen and that the periods of 0.3 and 0.4 second are harmonics of it, but he considers also the possibility that the period of 0.3 second is the free period of the uppermost layer, while the period of 1.2 seconds is the free period of a thicker crustal layer. The thickness of the first layer would be of the order of 2 kilometers. He tries to explain the fact that the prevailing period at Stuttgart is about 0.2 to 0.3 second, while at Ravensburg it is 0.5 to 0.6 second by the increase in thickness of the surface layer in approaching the Alps. At Ravensburg the thickness of the surface layer is estimated to be about 4 kilometers. Köhler also gives some data for other stations. In Jena, for example, periods between 0.26 and 0.43 second are especially frequent. At Potsdam periods in the neighborhood of 0.41 second prevail. Microseisms at places west of Potsdam show periods of sinusoidal waves between 0.35 and 0.37 second. At Zürich the prevailing period is 0.6 second, with a small secondary maximum at 1.2 seconds. Periods under 0.5 second are recorded there very infrequently. The period of 1.2 seconds which has been mentioned previously in discussing the periods at Göttingen is also frequently recorded at Jena and Pulkovo.

DATA

The fact that at Pasadena and its six auxiliary stations the same type of instruments are operated offers an unusual opportunity to compare periods recorded during different earthquakes at several localities. The constants of these stations are the following:

Pasadena:
Latitude=34°08.9′ N.; longitude=118°10.3′ W.; h=295 m.; deeply weathered granite rock, with inclusions of gneiss and schist.

Mount Wilson Seismologic Station:
Latitude=34°13.5′ N.; longitude=118°03.4′ W.; h=1,742 m.; weathered granite.

Riverside Seismologic Station:
Latitude=33°59.6′ N.; longitude=117°22.5′ W.; h=250 m., approx.; weathered granite.

Santa Barbara Seismologic Station:
Latitude=34°26.5′ N.; longitude=119°42.9′ W.; h=100 m., approx.; heavy, boulder-laden alluvium.

La Jolla (Scripps Institution Seismologic Station):
Latitude=32°51.8′ N.; longitude=117°15.2′ W.; h=7.7 m., approx.; consolidated detrital material.

Tinemaha Seismologic Station:
Latitude=37°05.7′ N.; longitude=118°15.5′ W.; h=1,180 m., approx.; basalt.

Haiwee Seismologic Station:
Latitude=36°08.2′ N.; longitude=117°57.9′ W.; h=1,100 m., approx.; loosely cemented tuff.

It is a well-known fact that in the case of continuous waves of a sinusoidal type the instruments have very different (dynamic) magnification for waves with different periods. For this reason, in the case of a wave train containing waves with different frequencies, the instruments accentuate those waves with periods for which their magnification is large. First, therefore, we have to consider the properties of the instruments used in this investigation.

Originally all stations had two Wood-Anderson horizontal component torsion seismometers with electromagnetic damping and optical recording (Cf. Bull. Seis. Soc. Am., XV, 1, 1925) with free periods of somewhat less than 1 second, static magnification between 2,500 and 3,000, and almost critical damping. During recent years one Benioff vertical component seismometer with galvanometric-optical recording has been added at each station. This seismometer has an inertia-mass of 100 kilograms, a free period between 0.5 and 1 second, about critical damping, and a galvanometer with a free period of about 0.2 second. The torsion seismometers have their maximum magnification for continuous sinusoidal waves with periods less than 0.5 second. In the case of sinusoidal waves with longer periods the magnification decreases and reaches about half the maximum value with periods of 1 second and about one-tenth with periods of 3 seconds. The Benioff vertical combination mentioned above gives its maximum magnification for sinusoidal waves with periods between 0.1 and 0.4 second. The magnification drops down somewhat faster than it does in the case of the torsion instruments and is about one-tenth of the maximum magnification for waves with periods of 1 second. Beside these instruments, at Pasadena short-period horizontal instruments with slightly different properties have been used temporarily. Examples of these are the horizontal instruments of the Benioff type with short-period galvanometers and the Benioff short-period strain seismograph.[1]

At Pasadena the following group of long-period instruments have been in use: One or two torsion instruments with free periods of 6 seconds or more, Benioff horizontal and vertical instruments, and a long-period Strain seismograph. The maximum magnification of the long-period torsion seismometers occurs for all waves with periods less than 3 seconds. Most of the long period Benioff combinations have their maximum magnification for continuous sinusoidal waves with periods between 0.4 and 1 second. It is smaller for shorter and longer waves, being about one-half for waves with periods of 0.1 to 2 seconds.

For the present investigations the records of Pasadena have been separated into two groups, one containing the short-period instruments and the other containing all long-period instruments. Besides the instruments mentioned so far, the geophysical outfit of the Cali-

[1] H. Benioff, A Linear Strain Seismograph, Bulletin of the Seismological Society of America, vol. 25, 1935, p. 283.

fornia Institute of Technology was used during the days following the Long Beach earthquake to record aftershocks. It proved very clearly that waves with periods as small as 0.01 second occur during all phases of local shocks. As earthquakes are frequently accompanied by audible sound waves, there is no doubt that waves with even shorter periods are produced during an earthquake, but as these waves are of no interest in engineering problems we will not deal during these investigations with waves having periods less than 0.1 second. On the other hand, very long waves with periods of a large fraction of a minute have been found occasionally in records of close-by shocks. The study of these long waves also is omitted in the investigation.

TABLE 29.—*List of shocks*

No.	Date	Greenwich standard time	Epicenter	Distance in kilometers						
				Pasadena	Mount Wilson	Santa Barbara	La Jolla	Riverside	Tinemaha	Haiwee
		h. m.								
1	Feb. 11, 1932	23 11	San Bernardino Mountains	130	116	262	186	77	208	202
2	Jan. 16, 1930	00 24	do	122	112	264	142	37	350	242
3	do	00 34	do	122	112	264	142	37	350	242
4	June 1, 1931	08 30	Mohave Desert	165	154	300	240	114	300	203
5	Aug. 17, 1930	22 07	do	173	150	278	270	146	235	140
6	Jan. 8, 1931	13 53	do	137	-------	253	-------	109	262	155
7	Feb. 24, 1930	19 56	do	139	124	-------	-------	111	258	155
8	Apr. 20, 1930	08 52	do	117	103	245	197	75	286	181
9	Apr. 27, 1931	23 08	Twenty-nine Palms	186	170	320	186	110	-------	249
10	Apr. 24, 1931	18 28	Redondo	49	63	132	153	108	366	------
11	Apr. 23, 1931	23 34	North of Barstow	178	144	250	302	178	179	70
12	Feb. 21, 1931	19 27	South of Bakersfield	145	-------	124	-------	204	205	------
13	Apr. 23, 1931	10 01	West of Parkfield	288	-------	175	-------	362	250	244
14	Aug. 18, 1930	13 09	West of Santa Barbara	188	140	45	324	267	320	279
15	Aug. 5, 1930	11 25	Near Santa Barbara	135	145	18	302	205	326	230
16	May 29, 1930	07 12	Panamint Valley	176	163	257	292	170	194	80
17	May 12, 1930	17 26	East of La Jolla	178	168	308	60	108	454	339
18	Apr. 29, 1931	12 41	Chatsworth	44	54	100	200	123	300	216
19	Jan. 17, 1931	08 08	Northeast of Bishop	381	-------	381	524	403	59	162
20	Nov. 28, 1929	19 53	50 kilometers west of Bishop	360	346	320	520	350	64	180
21	Aug. 31, 1930	00 40	Santa Monica	46	40	113	176	107	354	247
22	Nov. 9, 1929	02 31	Parkfield	276	280	168	436	347	235	235
23	June 8, 1934	04 31	do	289	292	179	451	355	237	226
24	do	04 49	do	289	292	179	451	355	237	226
25	do	05 44	do	289	292	179	451	355	237	226
26	Oct. 2, 1934	20 32	San Francisco	557	558	440	-------	560	380	440
27	do	20 22	do	557	558	440	-------	560	380	440
28	Oct. 31, 1929	19 39	San Pedro Channel	54	60	165	123	86	378	274
29	Sept. 13, 1929	13 23	do	54	60	165	123	86	378	274
30	Feb. 26, 1930	00 42	Brawley	270	250	410	-------	190	510	404
31	do	00 57	do	270	250	410	-------	190	510	404
32	do	01 23	do	270	250	410	-------	190	510	404
33	do	02 29	do	270	250	410	-------	190	510	404
34	do	04 23	do	270	250	410	-------	190	510	404
35	do	07 38	do	270	250	410	-------	190	510	404
36	Mar. 1, 1930	23 44	do	-------	-------	420	-------	200	510	410
37	Mar. 2, 1930	00 31	do	-------	-------	420	-------	200	510	410
38	do	01 49	do	-------	-------	420	-------	200	510	410
39	Nov. 28, 1929	19 50	50 kilometers west of Bishop	360	346	320	520	350	64	180
40	Sept. 26, 1929	20 00	East of Barstow	171	157	295	226	122	291	180
41	Jan. 2, 1931	01 53	West coast of Mexico	2,053	2,060	2,190	-------	1,970	2,770	2,210
42	Apr. 9, 1933	04 02	do	2,220	2,220	2,340	2,150	2,150	2,540	2,420
43	do	21 07	do	2,220	2,220	2,340	2,150	2,150	2,540	2,420
44	Dec. 7, 1932	16 27	do	2,220	2,220	2,340	2,150	2,150	2,540	2,420
45	July 10, 1933	03 27	do	2,442	-------	-------	-------	-------	-------	------

TABLE 29.—*List of shocks*—Continued

No.	Date	Greenwich standard time		Epicenter	Distance in kilometers						
					Pasadena	Mount Wilson	Santa Barbara	La Jolla	Riverside	Tinemaha	Haiwee
46	Jan. 4, 1933	21	13	Pacific Ocean	1,000	1,000	950	950	1,020	1,260	1,200
47	do	21	12	do	1,000	------	------	------	------	------	------
48	Aug. 16, 1931	11	43	Texas	1,355	1,355	1,505	------	1,285	1,455	1,400
49	Oct. 1, 1931	11	47	Gulf of California	555	555	680	390	170	870	730
50	July 12, 1932	19	27	do	1,221	1,221	1,365	1,060	1,150	1,540	1,440
51	Nov. 25, 1934	08	19	Lower California	272	274	388	107	224	575	465
52	July 7, 1932	16	17	do	777	------	890	610	720	1,065	955
53	May 26, 1929	22	44	Queen Charlotte Islands	2,209	2,209	2,070	2,370	2,280	------	------
54	Sept. 17, 1929	19	21	do	2,209	2,209	2,070	2,370	2,280	1,890	2,000
55	Mar. 11, 1933	01	55	Long Beach	60	68	183	106	70	380	276
56	do	06	59	do	60	68	183	106	70	380	276
57	Mar. 12, 1933	00	28	do	60	68	183	106	70	380	276
58	Mar. 11, 1933	22	00	do	60	68	183	106	70	380	276
59	do	22	41	do	60	68	183	106	70	380	276
60	do	23	33	do	60	68	183	106	70	380	276
61	do	15	02	do	60	68	183	106	70	380	276
62	Mar. 12, 1933	17	39	do	60	68	183	106	79	380	276
63	do	18	26	do	60	68	183	106	70	380	276
64	Mar. 13, 1933	04	33	do	60	68	183	106	70	380	276
65	Mar. 12, 1933	23	54	do	60	68	183	106	70	380	276
66	Mar. 13, 1933	13	18	do	60	68	183	106	70	380	276
67	do	19	30	do	60	68	183	106	70	380	276
68	Mar. 14, 1933	00	37	------	60	68	183	106	70	380	276
69	do	12	19	do	60	68	183	106	70	380	276
70	do	19	02	do	60	68	183	106	70	380	276
71	do	22	43	do	60	68	183	106	70	380	276
72	Mar. 15, 1933	04	33	do	60	68	183	106	70	380	276
73	do	05	41	do	60	68	183	106	70	380	276
74	do	23	14	do	60	68	183	106	70	380	276
75	Oct. 2, 1933	09	11	do	41	50	163	131	74	367	261
76	May 5, 1929	00	07	Whittier	29	35	163	137	58	------	------
77	do	06	23	do	29	35	163	137	58	------	------
78	July 8, 1929	16	46	do	29	35	163	137	58	------	------
79	do	17	05	do	29	35	163	137	58	------	------
80	do	17	21	do	29	35	163	137	58	------	------
81	do	17	46	do	29	35	163	137	58	------	------
82	do	21	36	do	29	35	163	137	58	------	------
83	July 9, 1929	00	22	do	29	35	163	137	58	------	------
84	do	04	24	do	29	35	163	137	58	------	------
85	do	04	59	do	29	35	163	137	58	------	------
86	do	08	03	do	29	35	163	137	58	------	------
87	Mar. 17, 1933	16	52	Long Beach	60	68	183	106	70	380	276
88	Jan. 30, 1934	19	25	Nevada	465	456	450	614	490	140	250
89	do	20	17	do	465	456	450	614	490	140	250
90	do	21	05	do	465	456	450	614	490	140	250
91	do	23	41	do	465	456	450	614	490	140	250
92	Jan. 31, 1934	00	26	do	465	456	450	614	490	140	250
93	do	03	56	do	465	456	450	614	490	140	250
94	do	14	28	do	465	456	450	614	490	140	250
95	Feb. 1, 1934	11	02	do	465	456	450	614	490	140	250
96	do	11	47	do	465	456	450	614	490	140	250
97	Dec. 20, 1932	20	11	do	514	507	510	658	535	192	296
98	Dec. 21, 1932	07	42	do	514	507	510	658	535	192	296
99	do	08	49	do	514	507	510	658	535	192	296
100	do	11	34	do	514	507	510	658	535	192	296
101	do	14	40	do	514	507	510	658	535	192	296
102	June 25, 1933	20	47	do	574	568	------	730	610	258	366
103	Mar. 12, 1934	15	08	Utah	980	970	1,030	1,080	970	720	800
104	do	18	23	do	980	970	1,030	1,080	970	720	800
105	May 6, 1934	08	12	do	980	970	1,030	1,080	970	720	800
106	Apr. 7, 1934	02	16	do	980	970	1,030	1,080	970	720	800
107	Nov. 9, 1927	04	20	Point Arguello	235	------	110	365	310	------	------
108	Feb. 1, 1934	11	20	Nevada	465	456	450	614	409	140	250

Records of 108 shocks which are listed in table 29 have been measured for all stations as far as available. Table 29 contains a list of these shocks and the approximate distances of the stations from the epicenter. As the accurate distances were not needed in the present investigation the closest values available from previous investigations have been used without further examination of the accuracy. Many of the distances have been computed by using the epicenters given by Dr. Richter in the "Monthly Report on Local Earthquakes, Pasadena." These shocks did not provide data concerning earthquakes nearer than 50 kilometers to Tinemaha, Haiwee, and La Jolla. Therefore, besides the shocks listed in table 29, small shocks originating within this distance from the stations have been investigated. In a similar way records of 22 blasts recorded at Pasadena and four of the outside stations have been investigated. The constants concerning these blasts are given in table 30. Table 31 gives a list of the seismograms on which periods of microseisms have been measured. Altogether, over 2,000 records have been investigated.

TABLE 30.—*List of blasts*

No.	Date	Epicenter	Distance in kilometers					
			Pasadena Long	Pasadena Short	Mount Wilson	Santa Barbara	La Jolla	Riverside
1	Oct. 21, 1923	Palos Verdes	-------	49	-------	-------	-------	-------
2	Apr. 27, 1924	Corona	-------	68	-------	-------	-------	-------
3	Dec. 8, 1924	Hollywood	-------	18	-------	-------	-------	-------
4	June 26, 1927	Monolith	112	112	-------	145	-------	158
5	Apr. 1, 1928	Slover Mountain	78	72	-------	-------	-------	8
6	Apr. 28, 1929	San Gabriel Dam	32	32	20	-------	-------	50
7	June 11, 1929	do	32	32	20	176	-------	50
8	June 15, 1929	Victorville	98	98	85	-------	195	85
9	June 26, 1929	San Gabriel Dam	32	32	20	176	162	50
10	Apr. 12, 1930	Glendora Road No. 1	30	30	-------	-------	-------	48
11	Apr. 12, 1930	Glendora Road No. 2	30	30	-------	-------	-------	48
12	Sept. 12, 1931	Victorville No. 2	98	98	84	-------	-------	72
13	Apr. 21, 1933	San Gabriel West Fork	32	32	20	176	-------	50
14	June 2, 1933	Signal Hill	41	41	48	-------	-------	-------
15	Oct. 27, 1934	do	-------	40±	-------	-------	-------	-------
16	Nov. 17, 1934	do	-------	40±	-------	-------	-------	-------
17	Dec. 6, 1930	Buena Vista No. 1	-------	-------	-------	-------	-------	2
18	do	Buena Vista No. 2	-------	-------	-------	-------	-------	2
19	Nov. 12, 1930	La Jolla Pit No. 1	-------	-------	-------	-------	1	-------
20	Nov. 13, 1930	La Jolla Pit No. 2	-------	-------	-------	-------	1	-------
21	Sept. 17, 1929	Skunk Point Blasts No. 1	-------	-------	-------	56	-------	-------
22	do	Skunk Point Blasts No. 2	-------	-------	-------	56	-------	-------

TABLE 31.—*Dates for which microseisms have been measured*

Pasadena	Mount Wilson	Haiwee	La Jolla
Nov. 20–21, 1934.	Sept. 30,-Oct. 1, 1934.	Aug. 9–10, 1934.	Dec. 16–17, 1934.
Aug. 27–28, 1934.	Sept. 28–29, 1934.	Aug. 13–14, 1934.	Dec. 13–14, 1934.
Sept. 5–6, 1934.	Sept. 26–27, 1934.	Aug. 8–9, 1934.	Dec. 9–10, 1934.
Sept. 10–11, 1934.	Sept. 15–16, 1934.	Aug. 5–6, 1934.	Dec. 4–5, 1934.
Oct. 4–5, 1934.	Sept. 12–13, 1934.	Aug. 3–4, 1934.	Nov. 30–Dec. 1, 1934
Oct. 13–14, 1934.	Sept. 2–3, 1934.	Aug. 1–2, 1934.	Nov. 26–27, 1934.
Dec. 16–17, 1934.	Aug. 31–Sept. 1, 1934.	Aug. 1–Sept. 1, 1934.	Nov. 20–21, 1934.
Nov. 18–19, 1934.	Aug. 29–30, 1934.	Aug. 29–30, 1934.	Nov. 15–16, 1934.
Nov. 21–22, 1934.	Aug. 16–17, 1934.	July 22–23, 1934.	Nov. 5–6, 1934.

Santa Barbara	Riverside	Tinemaha
Jan. 13–14, 1935.	July 11–17, 1934.	Dec. 2–3, 1934.
Jan. 12–13, 1935.	July 10–11, 1934.	Nov. 30–Dec. 1, 1934.
Jan. 11–12, 1935.	July 9–10, 1934.	Nov. 28–29, 1934.
Jan. 4–5, 1935.	July 8–9, 1934.	Nov. 27–28, 1934.
Dec. 31, 1934–Jan. 1, 1935.	July 5–6, 1934.	Nov. 15–16, 1934.
Dec. 22–24, 1934.	July 4–5, 1934.	Nov. 6–7, 1934.
Dec. 16–17, 1934.	July 29–30, 1934.	Nov. 3–4, 1934.
Dec. 12–13, 1934.	June 27–28, 1934.	Oct. 21–22, 1934.
Dec. 10–11, 1934.	June 20–21, 1934.	Oct. 12–18, 1934.

THE PERIODS MEASURED IN RECORDS OF EARTHQUAKES

In each record a certain number of periods has been measured concerning the P-phase, the S-phase, and the maximum phase. For shocks less than 100 kilometers distant there is usually no clear distinction between "S" and "M." In these cases the first waves of the large phase have been called "S" and the later waves "M." All measurements were finished before calculations were begun in order to avoid any influence of known data on the measurements. For each phase on each seismogram the number of occurrences of each period found in that phase has been tabulated. It is not possible to reproduce the results of these measurements in extenso in this paper. Table 32 gives the complete data concerning the short-period instruments at Pasadena while tables 33 to 38 show the tabulations concerning the outside stations for distances less than about 200 kilometers.

The outstanding result of these tabulations is that the periods which have been measured change very slightly between different shocks recorded from about the same distances at the same station and that they usually cover a very narrow range.

TABLE 32.—*Frequencies of periods recorded by the short-period instruments at Pasadena during the earthquakes listed in table 29*

The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

PASADENA P-PHASE

No.	Distance	Periods in seconds																				
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
	km																									
76	29		9	4	2	1	1																			
77	29		10	3	1	5	2	1	1																	
78	29				1	1			1																	
79	29	1	1	4	6	9																				
80	29		9	6	2																					
81	29		7	8		3																				
82	29		6	5	5																					
83	29		6	7	3	4	1																			
84	29			8	6	2																				
85	29		3	3	3	6	1																			
86	29		6	6	1																					
75	41	3	7	1		3	3	3	1	1	2															
18	44		8	6		7																				
21	46	2	12	15	2	2																				
10	49	5	7	9	6	8	4																			
28	54				2	4	3																			
29	54	6	8	5																						
56	60				4	5	1																			
57	60		3	3	5	9	4	1	1	2																
58	60			7	7	4																				
59	60			3	10	6																				
60	60		6	6	4	6	4																			
61	60		5	4	3	9	2																			
62	60	5	6	2	2	5	4																			
63	60	4	6	5	5	5																				
64	60		2	6	9	4																				
65	60	2			1	8	6	4																		
66	60	4	2	4	5	5	3					1														
67	60				5	12	1																			
68	60		1	5	5	10	3																			

TABLE 32.—*Frequencies of periods recorded by the short-period instruments at Pasadena during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

PASADENA P-PHASE—Continued

No.	Distance	Periods in seconds																								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
	km																									
69	60	1	3	2	7	8	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
70	60	-----	-----	1	8	7	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
71	60	-----	4	6	11	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
72	60	-----	3	3	8	7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
73	60	2	6	4	6	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
74	60	3	5	-----	1	7	4	-----	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
87	60	-----	2	9	7	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	117	1	6	9	10	15	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
2	122	-----	-----	-----	8	11	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	122	-----	1	4	6	8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1	130	12	14	4	7	8	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	135	5	-----	2	4	7	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	137	-----	2	3	1	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	139	-----	4	14	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
12	145	1	5	7	8	17	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	165	-----	1	5	10	14	7	2	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
40	171	-----	4	6	5	11	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	173	9	11	11	10	8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
16	176	2	4	2	5	8	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	178	1	3	4	11	12	6	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
17	178	5	6	7	7	7	3	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9	186	-----	3	6	8	9	6	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
14	188	4	6	2	5	9	7	2	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
107	235	-----	1	2	2	10	5	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
30	270	1	2	1	-----	5	7	6	3	1	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
31	270	-----	-----	1	1	2	6	6	4	3	2	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
32	270	3	5	5	6	9	5	5	3	1	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
33	270	3	4	4	6	8	7	-----	1	1	-----	2	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
34	270	-----	3	2	3	8	11	8	8	6	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
35	270	1	2	6	7	7	6	6	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

36	270		2	5	7	6		1	1	1	4															
37	270			1	1	10	6	2			1															
38	270				3	4	2																			
51	272			5	17	18	10	9	12	4	12	7	7	10		1	2	2			2					
13	288		2	2	2	8	3	3	4																	
23	289		8	4	1	12	14	8	5	1	6		2	1	2	3	3	1								
24	289		2	1		5	10	10	8	4	8	3	2	1	1	1	4	1	1							
25	289		3	2	2	8	11	16	6	3	2															
20	360		5	7	5	8	4																			
39	360		1	1	5	8	8																			
19	381	1	3	1		3	2	3			2															
88	465					2	3	5	5	5	11	6	4													
89	465					6	2	5	5	5	8	2	1	1		1										
90	465				2	4	4	4	6	6	4	3														
91	465						6	6	6	8	3	5														
92	465					1	4	4	3	5	10	3	1													
93	465				1	4	4	6	4	8	6	1														
94	465				2	6	5	5	6	7	3	2														
95	465			2	3	6	7	6	5	1	4	5	1		1											
96	465			1	4	6	1	5		3	7	5	4	3	1											
108	465			2	3	4	5	5	5		4	10	2	4												
97	514	3	10	8	4	6	8	10	6	4	6															
98	514	5	9	5	6	12	4	2	3	4	1	4														
99	514	1	3	4	5	9	9	5	4	6	5	4														
100	514	2	5	5	5	10	9	6	6	3	2															
101	514	2	10	8	5	7	6	6	7	2	8	1														
49	555				1	7	7	5	4	5	2		1													
26	557		1	4	2	1	1	3								1	1	2	1							
27	557					2	3	3	2																	
102	574			1	5	18	10	3		2	14	4	2													
52	777					2	2	5	3	5	11	13	5	3												
103	980						2	8	10	15	20	18	5	10	1	8		3								
104	980					5	8	10	9	9	21	23	6	2	2											
105	980					1		5	2	3	25	26	11	13	2	1	2									
106	980						4	8	5	7	20	17	1	5	2											
46	1,000	1	12	12	1																					
47	1,000			2		2	2	1	1		7	7	3	1												
50	1,221					3	5	4			7	4	4	4	1	7	3	4	2							
48	1,351						3	9	3		5	11	4	7	4	4		2								
41	2,053																	3	1	2	1	2	2			
53	2,209										2			3		8	7		2							
54	2,209									1	2	1		1		2	2	6	7	1	2					
42	2,220													1		4	2	3	1		5	4	1			
43	2,220												1	1		2		3	2	2						
44	2,220									1	2			1		1	3	9	4	1	3					
45	2,442							1			1	2	1	2	1	8	3	3								

TABLE 32.—*Frequencies of periods recorded by the short-period instruments at Pasadena during the earthquakes listed in table 29*—Continued

The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

PASADENA S-PHASE

No.	Distance	Periods in seconds																								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
	km																									
76	29		4	4	4	4	1	1	1																	
77	29		1	4	3	9	6	3	1																	
78	29				1	2	1	1	1	2																
79	29		3		4	9																				
80	29		3	6			2	1			1															
81	29		2		6	5	5																			
82	29		3	9	1	3	2		1																	
83	29		1	5	3	2	5	2																		
84	29			1	2	3	8	2																		
85	29			3	4	5	5	5	2																	
86	29		4	6	4	4	2																			
75	41	2	11	12	3	1																				
18	44		3	5	4	6	1	2	1																	
21	46		10	13	2	1	2	2																		
10	49	5	8	8	8	7	3	2	1																	
28	54					2	5	6	1																	
29	54	2	7	7																						
56	60				2	4	3	2																		
57	60					1	4	8	1	2																
58	60		1	2	7	5	2																			
59	60				3	8	7	2		1	1															
60	60					6	11	4																		
61	60					2	11	4	2																	
62	60	1	3	7	5	4																				
63	60				4	7	7	2																		
64	60				2	12	3																			
65	60			2	6	11	10	1																		
66	60				3	9	5																			
67	60				5	11	3																			
68	60				5	12	5																			

69	60				7	7	3	2																		
70	60				7	5	1	2	2		3															
71	60		1	4	11	3																				
72	60	1	1			4	3	1	2	2	3															
73	60		3	9		4	2	2	1																	
74	60						2	6	7	2																
87	60					5	4	3	4	1	1															
8	117	2	5	4	6	9	5																			
2	122				2	9	10																			
3	122				9	10	5																			
1	130	10	10	1	3	5	1	3	2																	
15	135	6	1	2	8	8	5	1																		
6	137		1	1	3	1	1	2																		
7	139		6	7		4																				
12	145		1	3	8	12	6	3																		
4	165	4	8	6	4	11	6	4	2	3	2	2														
40	171		2	6	7	9	7	2																		
5	173	7	10	10	9	6			1	1																
16	176	6	7	3	6	7	1																			
11	178	1	3	5	5	11	9	1	2																	
17	178	9	10	4	3	11	6	3	3	1																
9	186		1	1	5	11	9	4	1																	
14	188	5	6	4	4	4	1	2	2	4	4															
107	235					3	3	4	6		1	3														
30	270					3	8	7	5	5																
31	270					2		3	3	5	3	9	3													
32	270				2	4	7	8	6	4																
33	270	1	3	2	3	1		1	1	2	1	3	2	1	4	4	4									
34	270	1	3	3	3	6	9	7	5	2	1															
35	270					2	6	6	4	6	5	1														
36	270			1	8	10	1					1	2													
37	270					6	9	1	1	1	1															
38	270				1	8	9	1																		
51	272				5	11	7	5	8	4	7	4	2	4	1	2	1	1								
13	288		1		4	5	6	3	2																	
23	289		1	1	1	10	10	11	8	2	12	3	8	4	4	2										
24	289			1	1	7	4	3	2	1	7	5	7	10	3	4										
25	289					8	13	9	7	3	13	3	1													
20	360		2	3	4	5	4	3	2	3	5															
39	360			4	7	7	8	4	2	3	3															
19	381		1	4	1	4		1	1																	
88	465								4	4	4	11	3	2	2	3										
89	465					4	2	4	2	4	6	8	2													
90	465					3	8		8	6	4															
91	465					3	6		5	12	5	6														

TABLE 32.—*Frequencies of periods recorded by the short-period instruments at Pasadena during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

PASADENA S-PHASE—Continued

No.	Distance	Periods in seconds																								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
	km																									
92	465					2	1	5	4	5	7	7	2													
93	465					1	5	3	4	10	7	7														
94	465							7	4	8	11	11														
95	465					2	3	3	2	5	3	4	3	5	1	3		1								
96	465							2	2		1	7	9	13	4	5	1									
108	465					2	1	3	5		4	5	6	7	5	2	2									
97	514	1	3		2	5	9	8	6	4	6	3	1													
98	514	2	3	6	12	4	6	3	2	1	5	7	3		2											
99	514		2	3	4	11	13	6	1	5	7	2														
100	514		2	3	2	5	14	8	6	3	5	2	2	1												
101	514		2	2	5	10	15	8	2	3	6	2														
49	555				1	4	2	1	4	9	9		1	2		6	1									
26	557					3	3	1																		
27	557					2	3																			
102	574					7	10	7	7	4	10	7	3													
52	777					1	1	1		5	9	11	4	8	2	3	1				1	2				
103	980							3	7	3	6	14	12	12	7	2	5	10	5	1	1	1				
104	980					1	2	1	1	6	19	23	16	14		8										
105	980					2	2	1	1	1	9	13	9	17	13	5	7	3	3							
106	980					1		2	1	7	8	19		17	5	9	5	2								
46	1,000		7	8	5	1									2											
47	1,000			2	1	1	1	2			1	2		2	3	2	3	1								
50	1,221						1			3	4	6	6	7	3	2	3	4	2							
48	1,351										3	4	2	5	7	4	4	8	5	1	1	1				
41	2,053		1																3	4	2					
53	2,209																			1	2	12	1			
54	2,209																		1	3	1	1	4	2	2	
42	2,220																		1		2	3	2	1		
43	2,220											2						2	1			4				
44	2,220																	2	3			4	7	8		
45	2,442													2		1	2		1			3				

76	29	2		1	3	3	4	6	3	3	2	2														
77	29					5	3	8	5	3																
78	29							3	3	1	1	1														
79	29		3		8	9																				
80	29		4	1		3	7		5	1	1															
81	29				5	6	6	5	1			1														
82	29			8	4	3	4																			
83	29			4	4	3	3	4	1																	
84	29					3	2	4	8		4															
85	29			1		3	6	7	4	3		1														
86	29		5		2	2	6	1																		
75	41	1	7	1		1	4	5	2	2	9	10	5													
18	44			3		7	2	6	3	2	3															
21	46	4	8			6		1	1	3	1															
10	49	1	1	2	7	8	7	3	2	1																
28	54						1	3	4	2																
29	54	1	1	3	6	7	2																			
56	60	1		2	1	3																				
57	60						5	6	6	2	1															
58	60				2	8	6																			
59	60					1	6	3	5	3																
60	60						6	5	2	3	2															
61	60					1	7	2	3	3	2															
62	60	6	6		2	9	3	1		1	1	1														
63	60		2			2	5	6	4	1																
64	60				2	9	8																			
65	60						4	5	10																	
66	60				2		3	4	5	2	3	2														
67	60						3	6	7	3																
68	60						4	6	7																	
69	60					3	6	3	7																	
70	60						1	1	3	5	9	2														
71	60				3	4	5	3	2	2																
72	60					5	2	1	2	6	2															
73	60			1	2	6	8	1																		
74	60					1	2		2	6	5	4														
87	60				4	10	4																			
8	117		3	5	6	6	5																			
2	122					9	7	8	4																	
3	122					5	8	3	3	3	3	1														

TABLE 32.—*Frequencies of periods recorded by the short-period instruments at Pasadena during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

PASADENA M-PHASE—Continued

No.	Distance	Periods in seconds																								
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
	km																									
1	130	8	7	1	5	3	4	3	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
15	135	10	10	1	1	6	5	4	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
6	137	----	5	6	----	4	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
7	139	----	7	4	3	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12	145	----	1	3	6	9	1	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
4	165	----	1	2	4	8	8	4	4	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
40	171	----	----	----	1	10	7	----	----	1	10	6	----	1	----	----	----	----	----	----	----	----	----	----	----	----
5	173	1	8	12	12	12	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16	176	4	4	2	3	5	3	2	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
11	178	1	----	3	6	12	4	4	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17	178	----	1	3	3	5	7	3	6	4	2	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
9	186	----	2	2	6	8	6	3	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
14	188	1	5	5	6	5	4	3	2	1	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----
107	235	1	1	----	1	1	----	1	1	3	4	2	3	2	----	----	----	----	----	----	----	----	----	----	----	----
30	270	----	----	----	----	1	3	4	7	6	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
31	270	----	----	----	----	----	----	----	4	5	8	10	3	----	----	----	----	----	----	----	----	----	----	----	----	----
32	270	----	----	----	----	4	9	11	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
33	270	----	----	----	----	----	----	----	----	1	1	2	4	2	4	2	7	1	2	----	----	----	----	----	----	----
34	270	----	----	----	----	----	7	8	9	6	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
35	270	----	----	----	----	1	1	3	6	5	5	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----
36	270	----	----	1	----	4	3	----	6	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
37	270	----	----	----	----	1	4	4	2	1	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
38	270	----	----	----	----	4	7	2	2	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
51	272	----	----	----	5	12	7	5	8	4	12	13	9	15	6	2	3	1	2	3	2	1	----	----	----	----
13	288	1	1	----	----	3	1	3	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
23	289	----	----	----	----	----	4	1	4	5	12	8	5	1	4	4	2	2	1	1	----	----	----	----	----	----
24	289	----	----	----	----	1	1	----	1	1	1	6	8	9	3	1	3	2	1	----	5	----	----	----	----	----
25	289	----	----	----	----	1	1	4	6	9	20	3	8	1	2	----	----	----	----	----	----	----	----	----	----	----
20	360	----	----	3	6	3	4	5	4	1	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
39	360	----	3	5	5	5	3	3	4	4	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

19	381		3	1	1	3			2			2														
88	465											4	4	19	5	1										
89	465							2	3	6	5	4	1	5			1	2								
90	465						2	3	9	8	5	2														
91	465						4	3	4	6	8	12	5	2		2										
92	465					3	3	4	5	5	3		2	6												
93	465							3	5	10	11	7														
94	465							3	3	10	13	4														
95	465					2	5	2	3	2	5	4	5	11	2	2	1									
96	465								1			3	3	10		5	7	2	1	4	1					
108	465								1			7	6	11	4	7	3	4	5							
97	514		2	1		1	2	4		8	12	3	3	3												
98	514					1		1		3	10	19	12	4												
99	514					3	2	2	3	12	13	10	2	2		3										
100	514					5	4	3	1	6	12	13	5	3	2											
101	514	2			2	8	5	5	5	8	6	6			3	4										
49	555										1	3	2	4	1		2	10	7	1						
26	557					1	4	3																		
27	557							5	5																	
102	574						5	2	4	7	6	4	4	3	1	1										
52	777										1		1	3	1	5		2	7	1	1	12	3			
103	980											1		1		2	1	5	3	3	4	35	17	2		
104	980						1				5	6	4	10	3	6	2	2	5	1	5	25	1			
105	980								1		1	4	5	8	8	4	4	7	5		11	35	9			
106	980						2			3	8	6	1	7	5	4	7	13	2	2	2	13	1			
46	1,000																			2	5	5	6			
47	1,000															2		1			1	7	9	1		
50	1,221										3	3		1	1	3	2	2	1					1	12	
48	1,351										1			6	3	3	4	6	1	5	3	7	6	2		
41	2,053																								3	5
53	2,209																						3	13	1	
54	2,209																						8	8	2	
42	2,220																						1	5	4	
44	2,220																						2	11	14	
45	2,442																								6	8

TABLE 33.—*Frequencies of periods recorded at Riverside at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

RIVERSIDE P-PHASE

No.	Distance	Periods in seconds																			
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
	km																				
2	37	3	2	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
3	37	9	3	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
76	58	9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
77	58	2	5	5	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
78	58	4	6	6	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
79	58	5	5	5	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
80	58	9	7	5	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
81	58	9	8	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
82	58	7	6	5	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
83	58	7	6	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
84	58	14	4	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
85	58	6	7	3	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
86	58	13	3	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
57	70	2	4	2	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
58	70	6	4	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
59	70	14	---	---	---	8	3	---	10	---	---	---	---	---	---	---	---	---	---	---	---
60	70	10	8	2	6	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
61	70	2	2	8	8	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
62	70	4	8	8	10	4	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---
63	70	12	5	7	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
64	70	14	4	---	2	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---
65	70	16	1	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
66	70	8	5	4	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
67	70	9	---	7	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
68	70	2	12	11	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
69	70	5	11	4	---	---	---	---	---	---	4	---	---	2	2	---	---	---	---	---	---
70	70	5	5	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
71	70	9	8	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
72	70	11	9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
73	70	8	8	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
74	70	9	8	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
87	70	10	9	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
75	74	6	3	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
8	75	11	9	3	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1	77	3	3	4	4	3	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
29	86	---	4	1	3	9	4	1	1	---	---	---	---	---	---	---	---	---	---	---	---
28	86	4	9	5	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
21	107	---	1	5	2	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
10	108	---	1	4	4	5	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
17	108	7	7	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
6	109	1	11	7	4	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
7	111	---	5	5	---	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
4	114	---	4	1	2	9	4	1	1	---	---	---	---	---	---	---	---	---	---	---	---
40	122	---	---	---	7	5	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---
18	123	---	8	16	13	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
5	146	1	4	5	6	5	6	---	---	---	---	---	---	---	---	---	---	---	---	---	---
16	170	4	7	5	4	3	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
11	178	---	2	4	4	6	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
30	190	---	3	4	3	6	3	3	1	---	---	---	---	---	---	---	---	---	---	---	---
31	190	2	3	3	4	6	6	---	---	1	---	---	---	---	---	---	---	---	---	---	---
32	190	2	1	---	---	8	6	2	---	---	---	---	---	---	---	---	---	---	---	---	---
33	190	---	---	---	1	6	6	2	2	1	---	---	---	---	---	---	---	---	---	---	---
34	190	---	2	3	2	4	4	4	4	---	---	---	---	---	---	---	---	---	---	---	---
35	190	2	2	4	3	6	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---

TABLE 33.—*Frequencies of periods recorded at Riverside at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

RIVERSIDE S-PHASE

No.	Distance	Periods in seconds																			
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
	km																				
2	37	3	4	5	2	1	1														
3	37	3	4	3	2	1															
76	58	4	8	3	1																
77	58	6	7	3	2																
78	58	7	12																		
79	58		11	4																	
80	58		4	11	3																
81	58	5	10	3																	
82	58	3	10	5																	
83	58	2	10	8																	
84	58	5	12	4																	
85	58	4	11	4	2																
86	58	9	9	4																	
57	70	1	6	2																	
58	70	6	6		2	6	6	5													
59	70		12	8																	
60	70	4	11	4	3	3	3	2	2												
61	70		12	11																	
62	70	14	5	5	3	3	2		2												
63	70	9	9	3	2	3		2	2												
64	70		10	8		2															
65	70	9	2						2		2	1	1								
66	70		6	4	2																
67	70		14	6	2	1			2	2	2										
68	70	5	8	2																	
69	70	4	9	6	3						1	1	1	1	1						
70	70		13	7																	
71	70	5	10	4																	
72	70	4	10	7																	
73	70	9	6	4																	
74	70	6	10	3																	
87	70	5	12	4																	
75	74	8	4																		
8	75	7	4																		
1	77		1	4	3	4	2														
28	86	6	5	5	5																
29	86	2	5	5	1																
21	107			3	3	3	1														
10	108		3	3	3	4	1														
17	108	6	9	4	3																
6	109		3	8		3															
9	110		4	3		2	1	1		1	1										
7	111		6	6	6	8															
4	114	2	1	5	3	5	1	2													
40	122				1	5	4	1													
18	123	3	2	11	2	8	1	1													
5	146	3	4	5	7	11															
16	170	5	7	3	4	6															
11	178	3	4	3	1	7	3	1													
30	190				4	7	6	3	1												
31	190	4	5	3	4	5	3														
32	190	2	4	2	3	8	7	1													
33	190				3	4	3	1	3	1	3	2		2	1						
34	190	6	6	5	4	4															
35	190	3	2			2	3	2	2	4	3	1	2								

TABLE 33.—*Frequencies of periods recorded at Riverside at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

RIVERSIDE M-PHASE

No.	Distance	Periods in seconds																			
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
	km																				
2	37	3	9	4	3	2	3	----	2	2	2	----	----	----	----	----	----	----	----	----	----
3	37	7	5	----	3	11	4	----	4	3	5	----	----	----	----	----	----	----	----	----	----
77	58	----	5	1	7	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
78	58	----	7	5	4	5	4	2	----	----	----	----	----	----	----	----	----	----	----	----	----
79	58	1	8	6	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
80	58	2	9	8	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
81	58	3	9	5	4	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
82	58	5	13	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
83	58	7	10	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
84	58	2	7	13	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
85	58	4	12	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
57	70	9	1	1	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
58	70	3	4	4	----	1	6	7	2	3	2	1	----	----	----	----	----	----	----	----	----
59	70	----	9	5	----	----	----	2	----	3	1	----	----	----	----	----	----	----	----	----	----
60	70	----	6	----	4	5	7	4	----	----	----	----	----	----	----	----	----	----	----	----	----
61	70	----	6	----	----	----	3	----	2	4	5	2	----	----	2	----	----	----	----	----	----
62	70	7	3	----	1	5	5	5	3	3	----	----	----	----	----	----	----	----	----	----	----
63	70	----	6	----	3	6	4	3	----	----	----	----	----	----	----	----	----	----	----	----	----
64	70	----	6	----	----	----	3	1	2	5	2	5	3	3	2	----	----	----	----	----	----
65	70	6	6	3	----	----	----	----	1	1	4	3	2	1	1	1	4	----	----	----	----
66	70	----	9	----	----	4	2	----	1	3	3	----	----	4	3	1	----	3	----	----	----
67	70	----	6	----	2	4	6	1	3	----	2	1	3	----	----	----	----	----	----	----	----
68	70	6	6	----	----	----	----	----	----	4	2	4	6	5	----	----	----	----	----	----	----
69	70	6	6	----	3	5	----	----	----	----	3	2	5	6	----	----	----	----	----	----	----
70	70	3	2	----	----	4	2	2	4	3	3	----	----	----	----	----	----	----	----	----	----
71	70	4	9	4	1	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
72	70	5	4	6	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
73	70	9	5	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
74	70	4	8	6	3	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----
87	70	1	5	9	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
75	74	----	----	10	8	3	2	2	----	----	----	----	----	----	----	----	----	----	----	----	----
8	75	3	5	4	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1	77	----	4	2	5	6	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
28	86	8	8	6	3	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
29	86	----	5	5	5	5	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
21	107	----	----	9	2	1	5	3	2	1	----	----	----	----	----	----	----	----	----	----	----
10	108	1	4	6	4	5	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
17	108	8	12	1	1	----	1	1	1	3	----	----	----	----	----	----	----	----	----	----	----
6	109	2	6	4	2	2	2	1	----	----	----	----	----	----	----	----	----	----	----	----	----
9	110	----	5	4	4	6	3	3	2	1	----	----	----	----	----	----	----	----	----	----	----
7	111	----	4	5	6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
4	114	2	3	5	3	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
40	122	----	----	----	----	7	7	4	3	1	1	----	----	----	----	----	----	----	----	----	----
18	123	----	5	----	5	6	4	4	----	----	----	----	----	----	----	----	----	----	----	----	----
5	146	----	1	2	5	8	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
16	170	1	3	5	4	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
11	178	2	5	2	1	4	3	3	2	----	----	----	----	----	----	----	----	----	----	----	----
30	190	----	----	1	4	5	5	3	2	----	----	----	----	----	----	----	----	----	----	----	----
31	190	----	1	1	3	5	3	1	----	----	----	----	----	----	----	----	----	----	----	----	----
32	190	----	----	----	----	7	8	2	----	----	----	----	----	----	----	----	----	----	----	----	----
33	190	----	----	----	----	----	----	----	----	----	----	----	----	2	1	6	1	2	2	----	1
34	190	----	----	----	----	----	2	6	5	5	3	1	1	----	4	----	----	----	----	----	----
35	190	----	----	----	----	----	----	----	4	2	5	6	5	2	----	----	----	----	----	----	----

TABLE 34.—*Frequencies of periods recorded at Mount Wilson at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

MOUNT WILSON P-PHASE

No.	Distance	Periods in seconds												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6
	km													
76	35	----	14	7	----	----	----	----	----	----	----	----	----	----
77	35	----	11	6	----	----	----	----	----	----	----	----	----	----
78	35	----	----	----	5	3	----	----	----	----	----	----	----	----
79	35	----	5	6	2	----	----	----	----	----	----	----	----	----
80	35	3	14	4	1	----	----	----	----	----	----	----	----	----
81	35	1	14	5	2	----	----	----	----	----	----	----	----	----
82	35	2	10	8	2	----	----	----	----	----	----	----	----	----
83	35	2	9	10	----	----	----	----	----	----	----	----	----	----
84	35	2	15	1	5	----	----	----	----	----	----	----	----	----
85	35	----	9	2	----	----	----	----	----	----	----	----	----	----
86	35	----	8	6	----	----	----	----	----	----	----	----	----	----
21	40	----	7	7	1	2	----	----	----	----	----	----	----	----
75	50	5	3	----	1	1	----	----	----	----	----	----	----	----
18	54	2	3	6	3	----	----	----	----	----	----	----	----	----
28	60	4	5	5	4	4	----	----	----	----	----	----	----	----
29	60	5	4	1	----	----	----	----	----	----	----	----	----	----
10	63	9	8	5	9	10	5	----	----	----	----	----	----	----
57	68	----	7	7	3	----	----	----	----	----	----	----	----	----
58	68	----	14	10	1	1	----	----	----	----	----	----	----	----
59	68	4	17	4	3	----	----	----	----	----	----	----	----	----
60	68	11	12	2	----	----	----	----	----	----	----	----	----	----
61	68	6	14	4	----	----	----	----	----	----	----	----	----	----
62	68	14	11	2	----	----	----	----	----	----	----	----	----	----
63	68	12	9	3	----	----	----	----	----	----	----	----	----	----
64	68	----	8	5	----	----	----	----	----	----	----	----	----	----
65	68	----	8	2	----	----	----	----	----	----	----	----	----	----
66	68	----	5	5	----	----	----	----	----	----	----	----	----	----
67	68	7	9	2	----	----	----	----	----	----	----	----	----	----
68	68	9	16	2	----	----	----	----	----	----	----	----	----	----
69	68	----	10	13	5	2	----	----	----	----	----	----	----	----
70	68	----	14	10	2	----	----	----	----	----	----	----	----	----
71	68	----	3	14	7	3	2	----	----	----	----	----	----	----
72	68	7	12	8	5	----	----	----	----	----	----	----	----	----
73	68	----	18	4	----	----	----	----	----	----	----	----	----	----
74	68	2	15	7	----	2	----	----	----	----	----	----	----	----
87	68	4	15	9	2	----	----	----	----	----	----	----	----	----
8	103	8	8	4	----	----	----	----	----	----	----	----	----	----
2	112	----	2	3	5	6	----	----	----	----	----	----	----	----
3	112	----	1	4	7	7	1	----	----	----	----	----	----	----
1	116	----	5	9	4	2	----	2	----	----	----	----	----	----
7	124	----	3	8	1	3	----	----	----	----	----	----	----	----
14	140	2	2	4	2	2	3	2	2	1	----	----	----	----
11	144	----	2	1	6	6	4	1	1	----	----	----	----	----
15	145	5	7	8	3	1	----	----	----	----	----	----	----	----
5	150	5	10	5	2	1	----	----	----	----	----	----	----	----
4	154	----	4	8	5	3	----	----	----	----	----	----	----	----
40	157	1	7	8	4	2	----	----	----	----	----	----	----	----
16	163	3	6	8	4	2	----	----	----	----	----	----	----	----
17	168	6	9	5	5	1	1	----	----	----	----	----	----	----
9	170	----	2	8	3	7	----	----	----	----	----	----	----	----

TABLE 34.—*Frequencies of periods recorded at Mount Wilson at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

MOUNT WILSON S-PHASE

No.	Distance	Periods in seconds												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6
	km													
76	35	-----	9	8	4	-----	-----	-----	-----	-----	-----	-----	-----	-----
77	35	2	6	4	3	4	-----	-----	3	-----	-----	-----	-----	-----
78	35	-----	-----	-----	2	1	-----	-----	-----	-----	-----	-----	-----	-----
79	35	2	2	7	-----	2	-----	-----	-----	-----	-----	-----	-----	-----
80	35	10	10	3	5	4	-----	-----	-----	-----	-----	-----	-----	-----
81	35	-----	10	6	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
82	35	-----	8	13	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
83	35	-----	10	10	3	2	-----	-----	-----	-----	-----	-----	-----	-----
84	35	3	10	7	1	1	-----	-----	-----	-----	-----	-----	-----	-----
85	35	-----	4	7	3	3	-----	-----	-----	-----	-----	-----	-----	-----
86	35	-----	3	8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
21	40	-----	3	9	1	7	2	-----	-----	-----	-----	-----	-----	-----
75	50	-----	-----	-----	1	7	1	-----	-----	-----	-----	-----	-----	-----
18	54	2	2	2	2	3	1	-----	-----	-----	-----	-----	-----	-----
28	60	2	4	5	5	4	-----	-----	-----	-----	-----	-----	-----	-----
29	60	3	3	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	63	4	4	8	13	13	7	-----	-----	-----	-----	-----	-----	-----
57	68	2	-----	6	6	3	-----	-----	-----	-----	-----	-----	-----	-----
58	68	-----	9	5	10	1	-----	-----	-----	-----	-----	-----	-----	-----
59	68	-----	10	9	6	-----	-----	-----	-----	-----	1	-----	-----	-----
60	68	-----	6	12	5	2	-----	-----	-----	-----	-----	-----	-----	-----
61	68	-----	14	10	2	-----	-----	-----	-----	1	-----	-----	-----	-----
62	68	-----	3	4	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
63	68	-----	6	15	4	-----	-----	-----	-----	-----	-----	-----	-----	-----
64	68	-----	-----	7	3	1	1	1	-----	-----	-----	-----	-----	-----
65	68	-----	1	8	2	1	-----	-----	-----	-----	-----	-----	-----	-----
66	68	-----	5	6	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
67	68	-----	7	5	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
68	68	3	12	13	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
69	68	-----	11	13	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
70	68	2	9	14	11	-----	-----	-----	-----	-----	-----	-----	-----	-----
71	68	3	10	10	5	3	2	-----	-----	-----	-----	-----	-----	-----
72	68	4	8	9	2	4	1	-----	-----	-----	-----	-----	-----	-----
73	68	-----	15	8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
74	68	-----	17	8	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
87	68	-----	14	11	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	103	6	7	6	2	1	-----	-----	-----	-----	-----	-----	-----	-----
2	112	-----	-----	1	4	8	4	-----	-----	-----	-----	-----	-----	-----
3	112	-----	2	4	8	8	1	-----	-----	-----	-----	-----	-----	-----
1	116	-----	1	5	6	4	3	2	1	-----	1	-----	-----	-----
7	124	-----	-----	1	1	1	-----	-----	-----	-----	-----	-----	-----	-----
14	140	5	5	6	3	2	3	3	2	3	1	-----	-----	-----
11	144	3	2	2	2	7	1	-----	-----	-----	-----	-----	-----	-----
15	145	5	7	8	3	2	2	-----	-----	-----	-----	-----	-----	-----
5	150	7	8	6	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	154	-----	1	5	6	9	-----	-----	-----	-----	-----	-----	-----	-----
40	157	-----	4	5	8	2	-----	-----	-----	-----	-----	-----	-----	-----
16	163	5	2	3	8	7	1	-----	-----	-----	-----	-----	-----	-----
17	168	2	7	6	3	2	2	-----	-----	-----	-----	-----	-----	-----
9	170	-----	-----	2	5	8	4	2	-----	-----	-----	-----	-----	-----

TABLE 34.—*Frequencies of periods recorded at Mount Wilson at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

MOUNT WILSON M-PHASE—Continued

No.	Distance	Periods in seconds												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6
	km													
76	35	6	4	-----	1	1	2	-----	1	-----	5	4	4	4
77	35	-----	2	-----	-----	9	8	3	3	1	-----	1	-----	-----
78	35	-----	3	3	3	9	6	-----	-----	-----	-----	-----	-----	-----
79	35	-----	6	2	-----	-----	2	1	-----	-----	2	-----	-----	-----
80	35	-----	16	4	1	1	-----	1	2	-----	-----	-----	-----	-----
81	35	-----	2	9	8	2	1	1	1	-----	-----	-----	-----	-----
82	35	-----	4	15	2	5	-----	-----	-----	-----	-----	-----	-----	-----
83	35	-----	15	9	3	4	-----	-----	-----	-----	-----	-----	-----	-----
84	35	1	9	6	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
85	35	1	3	7	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
86	35	-----	9	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
21	40	-----	-----	2	3	3	2	4	3	-----	-----	-----	-----	-----
75	50	-----	-----	-----	4	5	-----	-----	-----	-----	-----	-----	-----	-----
18	54	-----	-----	3	2	3	1	2	1	2	1	-----	-----	-----
28	60	-----	-----	1	8	9	-----	-----	-----	-----	1	-----	-----	-----
29	60	-----	-----	-----	6	3	-----	-----	-----	-----	-----	-----	-----	-----
10	63	3	8	9	6	7	3	2	1	1	-----	-----	-----	-----
57	68	-----	2	4	2	-----	-----	1	1	3	1	1	-----	-----
58	68	-----	6	7	3	6	4	-----	-----	-----	-----	-----	-----	-----
59	68	-----	3	10	4	4	2	-----	-----	-----	-----	-----	-----	-----
60	68	-----	2	6	4	4	6	2	-----	-----	-----	-----	-----	-----
61	68	-----	3	11	8	5	-----	-----	-----	-----	-----	-----	-----	-----
62	68	-----	4	2	-----	1	1	-----	-----	1	2	-----	-----	-----
63	68	-----	3	6	4	7	2	1	-----	-----	-----	-----	-----	-----
64	68	-----	1	2	6	2	-----	-----	-----	-----	-----	-----	-----	-----
65	68	-----	6	3	3	4	-----	-----	-----	-----	-----	-----	-----	-----
66	68	-----	1	4	5	1	-----	-----	-----	-----	-----	-----	-----	-----
67	68	-----	2	9	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
68	68	-----	8	13	4	1	-----	-----	-----	-----	-----	-----	-----	-----
69	68	4	7	7	1	-----	-----	-----	-----	4	1	-----	-----	-----
70	68	-----	8	5	4	3	-----	-----	-----	2	5	4	-----	-----
71	68	4	9	6	2	2	3	2	2	2	-----	-----	-----	-----
72	68	8	1	3	2	-----	4	2	-----	3	-----	1	-----	-----
73	68	-----	9	12	1	1	-----	-----	-----	-----	-----	-----	-----	-----
74	68	-----	12	4	-----	-----	-----	2	-----	3	3	-----	-----	1
87	68	-----	11	11	2	-----	-----	2	-----	2	-----	-----	-----	-----
8	103	-----	5	7	5	1	-----	-----	-----	-----	-----	-----	-----	-----
2	112	-----	-----	-----	3	8	8	-----	2	1	1	-----	-----	-----
3	112	-----	-----	-----	7	10	3	3	-----	-----	-----	-----	-----	-----
1	116	-----	4	2	3	3	2	-----	5	2	2	-----	-----	-----
7	124	-----	3	5	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
14	140	1	1	3	3	6	5	1	1	-----	-----	-----	-----	-----
11	144	-----	3	4	4	7	1	-----	-----	-----	-----	-----	-----	-----
15	145	-----	-----	2	8	8	5	1	-----	-----	-----	-----	-----	-----
5	150	2	4	6	6	3	-----	-----	-----	-----	-----	-----	-----	-----
4	154	-----	2	7	3	3	3	-----	-----	-----	-----	2	-----	-----
40	157	-----	-----	-----	2	11	6	3	1	-----	-----	-----	-----	-----
16	163	1	6	6	5	4	2	3	-----	-----	-----	-----	-----	-----
17	168	4	5	4	4	6	2	-----	-----	-----	-----	-----	-----	-----
9	170	-----	1	8	3	7	3	1	1	1	-----	-----	-----	-----

TABLE 35.—*Frequencies of periods recorded at Santa Barbara at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

SANTA BARBARA P-PHASE

Number	Distance	Periods in seconds															
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4
	km																
15	18	5	10	5	----	----	----	----	----	----	----	----	----	----	----	----	----
14	45	3	4	3	3	6	1	----	----	----	----	----	----	----	----	----	----
18	100	3	18	3	8	3	----	----	----	----	----	----	----	----	----	----	----
107	110	----	1	2	----	5	5	----	----	----	----	----	----	----	----	----	----
21	113	4	4	1	2	2	----	1	----	1	----	----	----	----	----	----	----
12	124	----	1	3	6	7	1	----	----	----	----	----	----	----	----	----	----
10	132	----	2	2	2	7	4	3	2	----	----	----	----	----	----	----	----
75	163	----	2	2	----	6	7	12	6	4	3	4	----	----	----	----	----
76	163	----	4	2	----	4	4	3	1	1	1	----	----	----	----	----	----
77	163	----	----	1	3	1	6	2	----	----	2	----	----	----	----	----	----
78	163	----	----	----	1	4	2	----	----	----	----	----	----	----	----	----	----
79	163	----	4	3	3	9	2	2	----	----	----	----	----	----	----	----	----
80	163	----	2	3	3	7	5	----	----	----	----	----	----	----	----	----	----
81	163	----	2	7	6	6	----	----	----	----	----	----	----	----	----	----	----
32	163	----	----	2	5	10	4	----	----	----	----	----	----	----	----	----	----
84	163	----	----	----	10	9	----	----	----	----	----	----	----	----	----	----	----
85	163	----	----	----	5	12	2	----	----	----	----	----	----	----	----	----	----
28	165	----	1	4	3	11	3	----	----	----	----	----	----	----	----	----	----
29	165	2	2	3	6	6	2	----	----	----	----	----	----	----	----	----	----
22	168	----	2	6	3	6	4	4	1	----	----	----	----	----	----	----	----
13	175	----	1	2	3	7	4	2	----	----	----	----	----	----	----	----	----
23	179	----	----	1	----	9	12	11	5	1	1	----	----	----	----	----	----
24	179	----	----	3	3	6	6	6	4	2	3	----	----	----	----	----	----
25	179	----	----	2	5	6	8	5	3	----	2	1	----	----	----	----	----
56	183	----	----	10	7	6	----	----	----	----	----	----	----	----	----	----	----
57	183	----	----	----	1	10	4	2	----	----	----	----	----	----	----	----	----
58	183	----	----	----	9	10	4	----	----	----	----	----	----	----	----	----	----
59	183	----	----	----	4	9	7	2	----	----	----	----	----	----	----	----	----
60	183	----	----	----	----	8	7	2	----	----	----	----	----	----	----	----	----
61	183	----	----	----	1	11	5	2	----	----	----	----	----	----	----	----	----
62	183	----	----	1	6	10	----	----	----	----	----	----	----	----	----	----	----
63	183	----	----	----	5	11	4	----	----	----	----	----	----	----	----	----	----
64	183	----	----	2	7	11	2	2	----	----	----	----	----	----	----	----	----
65	183	----	----	----	6	10	5	----	----	----	----	----	----	----	----	----	----
66	183	----	----	----	----	9	11	----	----	----	----	----	----	----	----	----	----
67	183	----	----	2	8	14	----	----	----	----	----	----	----	----	----	----	----
68	183	----	----	----	8	10	1	----	----	----	----	----	----	----	----	----	----
69	183	----	----	----	4	15	3	----	----	----	----	----	----	----	----	----	----
70	183	----	2	2	7	10	5	----	----	----	----	----	----	----	----	----	----
71	183	----	----	2	10	8	----	----	----	----	----	----	----	----	----	----	----
72	183	----	----	3	8	8	2	----	----	----	----	----	----	----	----	----	----
73	183	----	2	4	6	8	1	----	----	----	----	----	----	----	----	----	----
74	183	----	----	----	2	11	10	----	----	----	----	----	----	----	----	----	----
87	183	----	----	----	8	13	3	----	----	----	----	----	----	----	----	----	----

TABLE 35.—*Frequencies of periods recorded at Santa Barbara at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

SANTA BARBARA S-PHASE

Number	Distance	Periods in seconds															
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4
	km																
15	18	3	3	5	----	4	1	2	2	1	----	----	----	----	----	----	----
14	45	----	2	1	4	5	5	1	----	----	----	----	----	----	----	----	----
18	100	3	8	7	2	3	3	2	3	----	----	----	----	----	----	----	----
107	110	----	2	3	1	1	1	1	2	----	----	----	----	----	----	----	----
21	113	----	3	3	3	8	2	4	2	----	----	----	----	----	----	----	----
12	124	----	----	----	3	10	5	2	----	----	----	----	----	----	----	----	----
10	132	----	----	3	4	8	6	1	----	----	----	----	----	----	----	----	----
75	163	----	----	4	11	4	9	9	5	5	2	----	----	----	----	----	----
76	163	----	----	----	----	----	----	2	1	3	2	1	----	2	----	----	----
77	163	----	----	----	----	3	2	----	3	3	3	----	1	----	----	----	----
79	163	----	----	----	5	9	7	4	----	----	----	----	----	----	----	----	----
80	163	----	----	----	3	7	6	1	----	----	----	----	----	----	----	----	----
81	163	----	----	----	3	13	3	2	----	----	----	----	----	----	----	----	----
82	163	----	----	----	----	10	8	----	----	----	----	----	----	----	----	----	----
84	163	----	3	----	----	3	5	----	----	----	----	----	----	----	----	----	----
85	163	----	----	----	2	8	4	----	----	----	----	----	----	----	----	----	----
28	165	----	----	----	5	12	4	----	----	----	----	----	----	----	----	----	----
29	165	----	----	5	3	5	5	----	----	----	----	----	----	----	----	----	----
22	168	----	----	8	3	6	2	5	1	----	----	----	----	----	----	----	----
13	175	----	3	----	3	7	6	3	2	----	----	----	----	----	----	----	----
23	179	----	----	3	3	5	5	5	5	2	7	----	----	----	----	----	----
24	179	----	----	1	1	4	1	4	2	----	4	----	2	----	----	----	----
25	179	----	----	----	2	9	5	4	4	3	5	----	1	----	----	----	----
56	183	----	----	----	1	2	8	2	3	----	2	----	----	----	----	----	----
57	183	----	----	----	1	9	7	1	----	----	----	----	----	----	----	----	----
58	183	----	----	----	2	10	9	----	2	----	----	----	----	----	----	----	----
59	183	----	----	----	----	3	11	5	----	----	----	----	----	----	----	----	----
60	183	----	----	----	----	2	13	6	----	----	----	----	----	----	----	----	----
61	183	----	----	----	2	6	8	----	----	----	----	----	----	----	----	----	----
62	183	----	----	----	----	4	7	6	----	----	----	----	----	----	----	----	----
63	183	----	----	----	8	2	9	----	----	----	----	----	----	----	----	----	----
64	183	----	----	1	5	7	1	----	----	----	----	----	----	----	----	----	----
65	183	----	----	----	----	3	9	4	1	----	----	----	----	----	----	----	----
66	183	----	----	----	2	7	6	----	----	----	----	----	----	----	----	----	----
67	183	----	----	----	2	12	7	----	----	----	----	----	----	----	----	----	----
68	183	----	----	----	3	10	2	3	----	----	----	----	----	----	----	----	----
69	183	----	----	----	----	12	9	4	----	----	----	----	----	----	----	----	----
70	183	----	----	----	2	5	11	2	----	----	----	----	----	----	----	----	----
71	183	----	----	----	----	----	7	6	5	1	----	----	----	----	----	----	----
72	183	----	----	----	2	10	7	----	----	----	----	----	----	----	----	----	----
73	183	----	2	2	6	7	8	----	----	----	----	----	----	----	----	----	----
74	183	10	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
87	183	----	----	----	----	12	8	----	----	----	----	----	----	----	----	----	----

TABLE 35.—*Frequencies of periods recorded at Santa Barbara at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

SANTA BARBARA M-PHASE

Number	Distance	Periods in seconds															
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4
	km																
15	18	----	----	----	----	----	1	1	2	8	8	6	----	----	----	----	----
14	45	----	----	----	----	2	5	4	2	3	2	----	----	----	----	----	----
18	100	3	6	4	2	5	----	6	3	4	3	----	----	----	----	----	----
107	110	----	----	----	----	----	3	2	3	3	3	3	2	----	----	----	----
21	113	----	3	6	----	----	2	5	1	3	2	1	1	----	----	----	----
12	124	----	----	2	1	6	3	1	----	----	----	----	----	----	----	----	----
10	132	----	----	1	----	7	4	3	2	2	----	----	----	----	----	----	----
75	163	----	----	----	----	7	4	7	7	4	6	9	----	----	----	----	----
76	163	----	----	----	2	3	3	----	2	----	2	2	----	----	----	----	----
77	163	----	----	----	----	2	1	5	3	----	2	2	----	----	----	----	----
78	163	----	----	----	----	3	3	2	2	2	----	----	----	----	----	----	----
79	163	----	----	----	----	2	6	6	----	----	----	----	----	----	----	----	----
80	163	----	----	5	----	10	4	----	----	----	----	----	----	----	----	----	----
81	163	----	----	----	3	12	2	1	----	----	----	----	----	----	----	----	----
82	163	----	2	2	5	8	4	----	----	----	----	----	----	----	----	----	----
84	163	----	----	----	3	7	5	3	----	----	----	----	----	----	----	----	----
85	163	----	----	----	3	6	6	----	----	----	----	----	----	----	----	----	----
28	165	----	----	----	----	5	7	4	2	1	----	----	----	----	----	----	----
29	165	----	----	----	----	5	4	4	5	1	----	----	----	----	----	----	----
22	168	----	----	----	----	2	6	5	6	3	----	----	----	----	----	----	----
13	175	----	----	3	2	6	----	1	1	3	3	----	----	----	----	----	----
23	179	----	----	----	1	3	3	5	4	7	8	6	1	----	----	----	----
24	179	----	----	----	1	5	1	2	1	1	8	5	3	6	1	2	1
25	179	----	----	----	1	8	8	5	5	1	3	2	1	----	----	----	----
56	183	----	----	----	----	1	2	4	1	2	4	2	----	----	----	----	----
57	183	----	----	----	----	4	5	5	1	----	1	1	----	----	----	----	----
58	183	----	----	----	----	----	14	7	----	----	----	----	----	----	----	----	----
59	183	----	----	----	----	----	----	9	7	5	----	----	----	----	----	----	----
60	183	----	----	----	----	5	9	6	2	----	----	----	----	----	----	----	----
61	183	----	----	----	----	2	8	7	4	----	----	----	----	----	----	----	----
62	183	----	----	----	----	2	4	6	4	----	----	----	----	----	----	----	----
63	183	----	----	----	1	4	3	4	7	4	----	----	----	----	----	----	----
64	183	----	----	----	----	4	9	4	3	2	----	----	----	----	----	----	----
65	183	----	----	----	----	----	----	5	9	6	----	----	----	----	----	----	----
66	183	----	----	----	----	5	7	3	1	----	----	----	----	----	----	----	----
67	183	----	----	----	----	5	8	6	2	----	----	----	----	----	----	----	----
68	183	----	----	----	----	4	8	6	1	----	----	----	----	----	----	----	----
69	183	----	----	----	----	----	2	7	6	4	3	----	----	----	----	----	----
70	183	----	----	----	----	----	----	3	5	5	7	1	----	----	----	----	----
71	183	----	----	----	----	4	3	4	6	7	----	----	----	----	----	----	----
72	183	----	----	----	----	6	6	7	3	----	----	----	----	----	----	----	----
73	183	----	----	----	----	5	7	6	6	----	----	----	----	----	----	----	----
74	183	----	----	----	----	----	----	6	8	7	----	----	----	----	----	----	----
87	183	----	3	----	----	3	8	6	5	2	----	----	----	----	----	----	----

TABLE 36.—*Frequencies of periods recorded at Haiwee at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

HAIWEE P-PHASE

No.	Distance	Periods in seconds											
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
	km												
11	70	2	4	5	4	2	-----	-----	-----	-----	-----	-----	-----
16	80	-----	2	1	3	5	-----	-----	-----	-----	-----	-----	-----
5	140	2	3	3	6	6	-----	-----	-----	-----	-----	-----	-----
6	155	-----	7	3	-----	5	4	1	1	-----	-----	-----	-----
7	155	-----	-----	3	2	7	5	-----	1	-----	2	-----	-----
19	162	-----	4	11	6	3	3	1	-----	-----	-----	-----	-----
20	180	2	-----	1	5	8	5	-----	-----	-----	-----	-----	-----
39	180	-----	5	3	7	8	1	-----	-----	-----	-----	-----	-----
40	180	-----	2	5	3	1	1	-----	-----	-----	-----	-----	-----
8	181	1	2	7	8	5	-----	-----	-----	-----	-----	-----	-----
1	202	-----	1	1	3	10	6	-----	-----	-----	-----	-----	-----
4	203	-----	2	2	6	7	4	-----	-----	-----	-----	-----	-----

HAIWEE S-PHASE

No.	Distance	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
11	70	-----	2	2	4	5	3	-----	-----	-----	-----	-----	-----
16	80	1	3	1	2	5	1	-----	-----	-----	-----	-----	-----
5	140	-----	1	1	2	6	4	4	2	-----	-----	-----	-----
6	155	-----	2	6	3	4	2	3	5	-----	-----	-----	-----
7	155	-----	-----	3	3	5	4	2	2	1	-----	-----	-----
19	162	-----	9	10	6	5	5	5	3	-----	-----	-----	-----
20	180	-----	-----	-----	4	8	8	3	-----	-----	-----	-----	-----
39	180	-----	-----	-----	1	10	9	-----	-----	-----	-----	-----	-----
40	180	-----	-----	-----	-----	1	3	2	3	1	1	-----	-----
8	181	-----	-----	1	4	8	6	1	-----	-----	-----	-----	-----
1	202	-----	-----	-----	3	3	4	4	7	3	-----	-----	-----
4	203	-----	-----	3	5	2	4	4	3	-----	-----	-----	-----

HAIWEE M-PHASE

No.	Distance	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
11	70	-----	2	2	2	4	3	3	1	2	-----	-----	-----
16	80	-----	-----	1	4	5	1	-----	-----	-----	-----	-----	-----
5	140	-----	-----	1	3	8	5	1	-----	-----	-----	-----	-----
6	155	-----	-----	3	-----	9	3	5	-----	2	2	1	-----
7	155	-----	-----	5	1	1	2	1	2	1	1	1	-----
19	162	-----	2	10	5	6	7	3	-----	-----	-----	-----	-----
20	180	-----	-----	-----	3	7	7	7	5	-----	-----	-----	-----
39	180	-----	-----	-----	-----	4	6	5	-----	4	4	-----	-----
40	180	-----	-----	-----	-----	-----	-----	-----	-----	-----	3	3	3
8	181	-----	-----	1	2	7	6	2	-----	-----	-----	-----	-----
1	202	1	-----	3	-----	2	4	3	4	4	1	-----	-----
4	203	-----	-----	3	2	6	3	1	4	2	-----	-----	-----

TABLE 37.—*Frequencies of periods recorded at Tinemaha at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

TINEMAHA P-PHASE

No.	Distance	Periods in seconds																			
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
	km																				
19	59	----	8	7	6	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
20	64	----	4	6	4	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
39	64	----	4	5	4	6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
88	140	----	2	4	1	3	7	6	6	4	----	----	----	----	----	----	----	----	----	----	----
89	140	----	2	2	8	13	7	----	----	----	----	----	----	----	----	----	----	----	----	----	----
90	140	----	7	15	6	4	3	4	----	----	----	----	----	----	----	----	----	----	----	----	----
91	140	----	5	4	7	9	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----
92	140	----	5	----	2	7	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
93	140	----	6	4	2	4	6	4	2	2	2	----	----	----	----	----	----	----	----	----	----
94	140	3	6	7	5	7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
95	140	----	5	4	5	10	8	----	----	----	----	----	----	----	----	----	----	----	----	----	----
96	140	----	3	2	5	13	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----
108	140	----	3	5	4	11	8	4	2	----	----	----	----	----	----	----	----	----	----	----	----
11	179	2	4	7	4	6	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
97	192	----	----	1	1	5	9	7	2	----	----	----	----	----	----	----	----	----	----	----	----
98	192	----	----	1	----	6	5	7	4	2	2	----	----	----	----	----	----	----	----	----	----
99	192	----	----	----	----	4	6	5	4	2	1	3	----	----	----	----	----	----	----	----	----
100	192	----	----	2	8	7	4	3	2	1	----	----	----	----	----	----	----	----	----	----	----
101	192	----	----	----	5	3	5	8	1	2	2	----	----	----	----	----	----	----	----	----	----
16	194	----	----	----	5	11	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
12	205	2	2	3	5	8	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1	208	----	----	1	1	4	3	1	1	----	----	----	----	----	----	----	----	----	----	----	----

TINEMAHA S-PHASE

No.	Distance	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
19	59	2	5	5	3	5	4	1	----	----	----	----	----	----	----	----	----	----	----	----	----
20	64	----	----	----	4	9	6	3	----	----	----	----	----	----	----	----	----	----	----	----	----
39	64	----	1	2	5	7	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----
88	140	----	----	----	4	10	9	3	5	----	----	----	----	----	----	----	----	----	----	----	----
89	140	----	----	----	2	4	1	2	3	2	3	1	----	----	----	----	----	----	----	----	----
90	140	----	4	----	7	9	9	4	2	----	----	----	----	----	----	----	----	----	----	----	----
91	140	----	4	2	15	7	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----
92	140	----	5	5	5	2	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----
93	140	----	4	4	3	2	8	3	4	2	----	----	----	----	----	----	----	----	----	----	----
94	140	----	5	5	5	11	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----
95	140	----	2	3	2	3	3	5	4	----	----	4	4	1	----	----	----	----	----	----	----
96	140	----	----	----	2	3	4	6	4	2	3	3	----	3	3	----	----	----	----	----	----
108	140	----	----	----	----	2	3	4	3	2	9	4	3	2	1	----	----	----	----	----	----
11	179	----	1	3	4	8	5	----	----	----	----	----	----	----	----	----	----	----	----	----	----
97	192	----	----	----	----	----	----	2	1	----	4	3	----	----	----	----	----	----	----	----	----
98	192	----	----	----	2	4	7	4	3	3	1	----	----	----	----	----	----	----	----	----	----
99	192	----	----	----	----	----	6	7	4	----	3	4	1	----	----	----	----	----	----	----	----
100	192	----	----	----	----	2	3	7	2	5	4	2	----	----	----	----	----	----	----	----	----
101	192	----	----	----	----	2	3	6	5	3	4	3	----	----	----	----	----	----	----	----	----
16	194	----	----	----	----	9	6	4	1	1	----	----	----	----	----	----	----	----	----	----	----
12	205	----	2	4	3	5	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1	208	----	----	----	----	2	2	4	1	1	----	----	----	----	----	----	----	----	----	----	----

TABLE 37.—*Frequencies of periods recorded at Tinemaha at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

TINEMAHA M-PHASE

No.	Distance	Periods in seconds																			
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4
	km																				
19	59		5	5	2	6	5	4	3	2											
20	64						3		2	2	6	3	2								
39	64									6	10	1									
88	140				4	8	11	3	3	4	2	1	1								
89	140				2	3	2	2	2	6	5	4		1	1	5	1	2			
90	140			5		9	4	8	6	1		2									
91	140			5	4	7	5	7	4												
92	140		6	6			8	5	1												
93	140			3	4	3	2	3	3	4	3	3									
94	140		1	2	4	7	5	2	2	2	3										
95	140				3	5	4	3	2	1	2	4	1	2	2	2		3	4		
96	140						2		2		3	6	4	9	2	2			3	1	
108	140				2	2		2	3	3	6	2	1	3	2	1		2	2	2	1
11	179		1	2	1	4	4	3	3	3	1										
97	192						1			1	1	3	3	2							
98	192					2	2		4	3	4	5	4	2							
99	192					1	2	3	2	2	2	8	4	2	1						
100	192					2	2	3	1	3	5	4		2	3						
101	192						2	1	1	3	4	6	4	3							
16	194					1	3	5	5	4	2	1									
12	205				3	6	5	3													
1	208				1	3	1	3	1	1	1										

TABLE 38.—*Frequencies of periods recorded at La Jolla at distances less than 200 kilometers during the earthquakes listed in table 29*

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

LA JOLLA P-PHASE

No.	Distance	Periods in seconds														
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0
	km.															
17	60	4	7		8	6										
56	106		4	8	6	1										
57	106			6	6	1	6	2		1	3	5				
58	106	3	5	8	7	1										
59	106		6	6	7	2										
60	106	2	4	2	2	1										
61	106	4	4	8	4											
62	106		2	9	8											
63	106	3	8	8	2											
64	106		3	6	9	4										
65	106			7	10	2										
66	106		4	9	7											
67	106		10	10												
68	106	9	7	6	5	2										
69	106	1	10	6	5											
70	106		5	5	2		2				2	2		1		
71	106		5	8	5											
72	106	4	10	4	1											
73	106		3	9	10											
74	106	8	3	6	9											

TABLE 38.—*Frequencies of periods recorded at La Jolla at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated vertically in the order of increasing distance]

LA JOLLA P-PHASE—Continued

No.	Distance	Periods in seconds														
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0
	km.															
87	106	1	2	10	7	1										
51	107			10	7	3										
28	123		2	4	9	8										
29	123	2	3	3												
75	131	2	3	3	8	12	3									
76	137		4	3	7	5										
77	137		9	6	3	2										
78	137			4	7	8										
79	137	3	7	5	2	1										
80	137		1	4	3											
81	137		5	8	6	2										
84	137		2	8	3	6	1									
85	137		2	1	2	4	5	5								
2	142		3	4	8	6										
3	142		4	3	5	10	2									
10	153		4	6	6	7										
21	176		6	6	2	9	2									
1	186		3		3	4	2									
9	186				4	8	7	2								
8	197	1	3	3	4	7										
18	200			6	8	8	6									

LA JOLLA S-PHASE

No.	Distance	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0
17	60			2	9	8	1									
56	106					2	3	2	1	1	1	3	1			
57	106					3	5	5	2							
58	106				5	11	2			1						
59	106	10	8	2												
60	106		2	4	3	2										
61	106	1	5	8	3	2										
62	106		2	5	10	4										
63	106			7	9	2										
64	106				4	9	7									
65	106				3	11	4									
66	106		4	6	7	2										
67	106		6	9	8	2										
68	106		5	10	5											
69	106	6	4	9	5	4										
70	106		2	3	7	6										
71	106			3	3	5	6	1								
72	106	6	8	9	4											
73	106		6	7	6											
74	106			9	7	4	2									
87	106			3	7	8										
28	123	1	2	4	9	6										
29	123			2	3	3	2									
75	131		3		10	13	3									
76	137		3	4	7	4										
77	137			4	3	3	2	2								
79	137				5	9	6	4								
80	137		3	3	3	1										
81	137		8	7												
84	137			3	3	5	6	3	1	3						
85	137			6	4	3	3	5		2						
2	142				3	12	9									
3	142				7	12	8									
10	153		4	3	4	7	3	1	1							
21	176		1	3	5	4	1	2	1	1						

TABLE 38.—*Frequencies of periods recorded at La Jolla at distances less than 200 kilometers during the earthquakes listed in table 29*—Continued

[The numbers in the first column correspond to those in table 29. The frequencies are tabulated verticaly in the order of increasing distance]

LA JOLLA S-PHASE—Continued

No.	Distance	Periods in seconds														
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0
	km.															
1	186				1	2	3	2	2	1						
9	186				3	4	6	6	4	1						
8	197			2	6	10	2									
18	200		1	5		7	4	2								

LA JOLLA M-PHASE

No.	Distance	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0
17	60		3	3	7	6										
56	106					1	2	2	5	3	3	2	2			
57	106					2	1	2	3	6	3					
58	106					3	6	6	4		1					
59	106					5	2	4	3	8	2	1				
60	106						1	3	5							
61	106				2	6	8	2	3							
62	106				7	8	3	2								
63	106				1	8	9									
64	106					2	5	2	7	4	2					
65	106					1	3	7	8	3						
66	106					2	8	7	4							
67	106				2	10	7	2								
68	106				4	11	7									
69	106				7	8	2									
70	106				2	5	3	6	5							
71	106					2	6	4	3							
72	106					4	7	7	3							
73	106				5	9	4									
74	106				4	5	6	7	4							
87	106			5	6	8										
51	107			2	2	10	2	8	9		5	4	1	2	2	1
28	123	3		4	7	9										
29	123				1	4	5	4								
75	131	2			4	14	6									
76	137			6	9	9	2	2								
77	137			3	3	3	1									
78	137					3	3	2	2	2						
79	137					2	6	6								
80	137		1	3	1											
81	137		2	5	3	4	2	1								
84	137			2		2	2	3	1	3						
85	137					1		3	3		4					
2	142					10	7	4	4	2						
3	142				3	8	6	3								
10	153	4	3	3		6	5	2	2							
21	176			1	7	3	3	5		1	2					
1	186		2				1	4	3	1						
9	186		3	1	3	6	5	2	1	1						
8	197			1	3	10	4									
18	200			4		1	5	6	3	1						

DIFFERENCES IN DIFFERENT COMPONENTS

O. Geussenhainer (see footnote on p. 163) found in his investigations on microseisms in Göttingen that the horizontal components showed the free periods of the ground more clearly than the vertical component. To investigate if the same is true concerning the periods in earthquakes, a part of the material has been treated separately for the three components, especially seismograms obtained at short epicentral distances. Unfortunately, it is only recently that vertical components have become available at our stations, so that the number of records of the vertical component is very much smaller than that of the horizontal components. Only intervals of distance have been used in this section for which a sufficient number of seismograms with vertical components—always more than 50 and if possible more than 100—were available. In considering the results we must always keep in mind that the constants of the vertical instruments differ from those of the horizontal. The special differences were mentioned in the section on "Data."

The two horizontal components in general agree very well, as may be seen from some of the following tabulations. Some other examples which make this fact clear are the following: At Riverside, out of over 300 seismograms for distances between 50 and 100 kilometers, 42 percent of the P-phases showed periods of 0.2 seconds in the north-south component, while the corresponding figure in the east-west component was 47 percent. For distances between 100 and 200 kilometers 27 percent out of about 200 seismograms had a period of 0.5 second in the P-phase in the north-south component and 26 percent in the east-west component. In the S-phase the dominant period for 50 to 100 kilometers (about 300 seismograms) was 0.2 second with 45 percent in the north-south component and 48 percent in the east-west component. In the range from 100 to 200 kilometers, 47 percent out of about 200 seismograms showed periods between 0.5 and 0.6 second in the north-south component and 51 percent in the east-west component. In the M-phase at distances between 50 and 100 kilometers the period of 0.2 second has been measured in 24 percent of the cases in the north-south component and 27 percent in the east-west component, while at distances between 100 and 200 kilometers 35 percent of the measurements in the north-south component and the same percentage in the east-west component showed periods of 0.5 and 0.6 second.

At Mount Wilson periods of 0.2 and 0.3 second prevail in all phases for distances between 0 and 50 kilometers as well as 50 to 100 kilometers, as shown in comparison 1, table 39. The corresponding frequencies for these periods and others at La Jolla and Santa Barbara are shown in comparisons 2 and 3, table 39. The most frequent periods are always shown in bold-face type.

TABLE 39.—*Relative frequency, in percent of occurrence, of various periods on different components*

[Bold-face numbers indicate the most frequent periods]

Comparison no.	Station	Distance	Phase	Component	Periods in seconds											
					0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
		km														
1	Mount Wilson	0 to 50	P	NS	1	**57**	35	7	1	0	0	0	0	0	0	0
		do	P	EW	14	**59**	16	6	6	0	0	0	0	0	0	0
		do	S	NS	0	36	**44**	7	11	1	0	1	0	0	0	0
		do	S	EW	3	30	**34**	13	15	2	0	2	0	0	0	0
		do	M	NS	1	**34**	25	7	11	6	3	2	1	5	1	1
		do	M	EW	3	**21**	18	12	17	10	6	6	0	3	3	2
		51 to 100	P	NS	9	**45**	32	11	3	0	0	0	0	0	0	0
		do	P	EW	11	**56**	25	4	3	1	0	0	0	0	0	0
		do	S	NS	3	**41**	**39**	11	5	2	0	0	0	0	0	0
		do	S	EW	2	33	**43**	15	6	0	0	0	0	0	0	0
		do	M	NS	1	**34**	**25**	7	11	6	3	2	1	5	1	1
		do	M	EW	2	16	**28**	19	17	7	3	1	5	2	1	0
2	La Jolla	101 to 200	P	NS	4	20	**32**	**25**	15	3	1	0	0	0	1	0
		do	P	EW	4	19	**29**	**25**	14	5	1	0	0	1	1	0
		do	S	NS	1	10	**25**	**26**	**23**	11	4	2	0	0	0	0
		do	S	EW	2	10	**20**	**23**	**26**	10	5	2	2	0	1	1
3	Santa Barbara	101 to 200	P	NS	1	3	8	23	**43**	16	5	2	0	0	0	0
		do	P	EW	0	2	9	21	**42**	18	5	2	1	1	0	0
		do	S	NS	0	1	2	7	**31**	**35**	12	4	2	5	1	0
		do	S	EW	0	1	4	17	**32**	**29**	10	4	1	1	0	0
4	Pasadena, short period	101 to 200	P	NS	3	11	15	24	**34**	11	3	1	0	0	0	0
		do	P	EW	3	10	14	20	**39**	13	1	0	0	0	0	0
		do	P	Vertical	5	20	**30**	19	20	4	2	0	0	0	0	0
		do	S	NS	2	9	13	19	**31**	18	4	2	2	0	1	0
		do	S	EW	3	7	5	10	**32**	22	10	7	2	2	0	0
		do	S	Vertical	4	19	**23**	**20**	**23**	8	2	0	0	0	0	1
		do	M	NS	3	11	13	15	**20**	11	4	7	8	5	2	0
		do	M	EW	1	4	4	7	**23**	**27**	15	10	3	4	2	0
		do	M	Vertical	1	9	20	20	**39**	11	0	1	0	0	0	0

TABLE 39.—*Relative frequency, in percent of occurrence, of various periods on different components*—Continued

[Bold-face numbers indicate the most frequent periods]

Comparison no.	Station	Distance	Phase	Component	Periods in seconds											
					0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
		km														
5	Pasadena, short period	201 to 300	P	Vertical	3	7	10	12	**14**	**17**	10	11	4	4	3	2
		do	P	All	1	5	6	9	**19**	**16**	13	9	4	6	2	2
		do	S	Vertical	2	5	6	6	**23**	**22**	17	10	2	5	3	0
		do	S	All	0	2	2	5	**16**	**17**	13	11	6	9	6	5
		401 to 600	P	Vertical	0	1	6	9	**24**	19	15	9	7	5	4	1
		do	P	All	2	5	5	6	**16**	13	12	10	9	13	8	2
		do	S	Vertical	0	1	0	1	12	**20**	16	9	**14**	9	5	2
		do	S	All	0	2	2	4	9	**14**	10	9	11	**14**	12	1
6	Pasadena, long period	101 to 200	P	NS	5	13	**20**	12	**29**	9	2	1	2	3	1	5
		do	P	EW	6	15	**21**	12	**25**	14	4	1	1	1	0	0
		do	P	Vertical	0	0	7	23	**50**	12	5	1	0	1	0	0
		do	S	NS	1	7	14	11	**21**	17	11	7	3	5	2	0
		do	S	EW	4	7	12	12	**21**	10	7	9	8	4	0	2
		do	S	Vertical	0	3	3	13	**36**	**24**	9	6	4	1	0	1
		do	M	NS	1	3	9	7	**20**	11	10	6	5	5	3	4
		do	M	EW	1	6	8	12	**16**	10	6	2	6	10	10	3
		do	M	Vertical	0	8	7	10	**26**	16	14	12	6	1	0	0
7	Haiwee	0 to 50	P	Horizontal	23	**43**	**28**	2	4	0	0	0	0	0	0	0
		do	P	Vertical	20	**34**	**30**	11	5	0	0	0	0	0	0	0
		do	S	Horizontal	6	**32**	**34**	7	18	1	1	0	0	0	0	0
		do	S	Vertical	16	**24**	**27**	18	16	0	0	0	0	0	0	0
		do	M	Horizontal	0	9	17	25	**36**	4	6	2	0	0	0	0
		do	M	Vertical	2	23	**36**	13	**23**	0	0	0	0	0	0	0
8	Tinemaha	do	P	Horizontal	15	**32**	28	13	12	0	0	0	0	0	0	0
		do	P	Vertical	24	**34**	22	14	6	0	0	0	0	0	0	0
		do	S	Horizontal	3	13	14	22	**44**	5	0	0	0	0	0	0
		do	S	Vertical	3	8	23	24	**41**	1	0	0	0	0	0	0
		do	M	Horizontal	0	0	3	6	**39**	35	9	5	1	3	0	0
		do	M	Vertical	0	4	10	27	**46**	13	0	0	0	0	0	0
9	do	101 to 200	P	NS	0	1	13	22	**27**	18	11	5	2	1	0	0
		do	P	EW	0	1	5	10	**31**	23	13	6	5	4	1	0
		do	P	Vertical	3	**47**	28	13	8	0	0	0	0	0	0	0
		do	S	NS	0	1	2	6	**18**	**20**	12	14	7	8	6	3
		do	S	EW	0	0	0	11	**21**	**23**	17	8	2	8	7	2
		do	S	Vertical	0	15	**18**	15	**18**	5	15	8	2	5	0	0
		do	M	NS	0	1	1	1	6	12	**14**	**15**	9	9	10	4
		do	M	EW	0	0	1	1	9	**17**	12	6	11	10	**14**	7
		do	M	Vertical	0	3	6	**24**	**25**	8	6	9	2	8	5	0

10	do	201 to 300	P	Vertical	0	13	21	8	**25**	14	15	4	0	0	0	0
		do	P	All	1	3	13	11	**30**	15	7	3	2	3	6	5
		do	S	Vertical	0	4	6	14	**27**	16	10	10	8	4	2	0
		do	S	All	2	4	6	8	**19**	14	11	9	7	7	8	3
		do	M	Vertical	0	2	4	11	**17**	**20**	13	7	11	7	9	0
		do	M	All	0	1	3	8	**19**	12	11	8	7	9	6	6
		301 to 400	P	Vertical	0	12	19	17	**34**	14	3	2	0	0	0	0
		do	P	All	1	5	10	12	**35**	20	11	4	1	1	0	0
		do	S	Vertical	0	0	3	9	**36**	**32**	15	5	1	0	0	0
		do	S	All	0	0	3	5	**25**	**27**	21	8	3	3	2	1
		do	M	Vertical	0	0	1	4	**28**	**26**	**25**	9	4	1	1	0
		do	M	All	0	1	3	3	14	**22**	**25**	12	8	5	2	1
		601 to 800	P	Vertical	0	0	3	6	**21**	**21**	**21**	11	8	6	2	0
		do	P	All	0	0	2	3	11	**17**	**17**	11	8	**14**	11	3
		do	S	Vertical	0	0	0	8	**36**	**27**	8	10	3	5	3	0
		do	S	All	0	0	0	3	**16**	**15**	12	8	7	**15**	9	4
		do	M	Vertical	0	0	0	0	8	11	9	13	3	**17**	8	10
		do	M	All	0	0	0	0	3	3	6	7	4	**14**	10	11

At Haiwee the dominant periods at distances between 50 and 200 kilometers are 0.5 to 0.6 second in the S- and M-phases. These periods have been measured in 62 percent of all cases of S in the east-west component and in 51 percent in the north-south component, while the corresponding figures for the M-phase are 50 percent in the east-west component and 45 percent in the north-south component.

Data sufficient to compare the frequencies in the vertical component with those in the horizontal components are available at Pasadena for distances between 100 and 200 kilometers. The results are shown in comparison 4, table 39.

The differences between the vertical components and the horizontal components may be due partly to the different sensitivity of the instruments. This is especially true for the P-phase, where the vertical component shows a prevailing period of 0.3 second while the horizontal components show a considerably larger percentage for a period of 0.5 second. At distances from 200 to 300 kilometers and from 400 to 600 kilometers in the P- and S-phases, the values in comparison 5 seem to indicate that in the vertical component the dominant periods of 0.5 to 0.6 second occur slightly more frequently than in the average of all components.

In the M-phase, on the other hand, the period of 1 second has been observed more frequently at these distances in the horizontal components than in the vertical component. The latter shows quite a scattering, the frequency for distances from 200 to 600 kilometers being higher than 10 percent for each of the periods from 0.7 to 1.1 seconds.

The records of the long-period vertical instruments at Pasadena again show the periods of 0.5 and 0.6 second more frequently than the corresponding horizontal components as may be seen from comparison 6, table 39.

At Mount Wilson the number of seismograms available in the vertical component is large enough only for earthquakes at distances between 400 and 600 kilometers. In the P-phase the vertical component shows periods of 0.5 and 0.6 second in 58 percent of the cases, while the corresponding value for all measurements is 48 percent.

In the S-phase the corresponding figures are 55 percent in the vertical component and 38 percent for all measurements. In the M-phase the periods do not show clearly dominant values either in the vertical component or in the average for all instruments. There is no noticeable difference between the different components.

The same interval of distance (400 to 600 kilometers) can be used for Riverside. The periods of 0.5 and 0.6 second have been measured in 44 percent of all P-waves in the vertical component while the corresponding value is 28 percent for all components. In the S-phase periods of 0.6 and 0.7 second have been found in 35 percent of all cases in the vertical component and in 23 percent of all measurements. In the M-phase neither the vertical component measurements nor any other measurements show clearly the dominant periods in that distance interval, but periods of 1 second are somewhat more frequent in the horizontal components, where they form more than 15 percent of the measurements, while in the vertical component periods of 0.6, 0.7, 0.8, 0.9, and 1.0 second are about equally frequent.

At La Jolla there are fewer data for the vertical component than for the other stations. For distances between 100 and 200 kilometers, the period of 0.5 second has been measured in 28 percent of the cases concerning the vertical component of the M-phase, while the corresponding values are 24 percent for the east-west component, and 29 percent for the north-south component.

At Santa Barbara about 50 measurements are available for the vertical component at distances between 100 and 200 kilometers. The scanty data show periods of 1.0 and 1.1 seconds with noticeably greater frequency in the vertical component of the M-phase than in the horizontal components. In the first this frequency is 44 percent while the corresponding values for the east-west and north-south components are 4 percent and 5 percent respectively. At distances between 400 and 600 kilometers, on the other hand, the differences between the components are small.

At Haiwee measurements made especially on records of nearby shocks contain a relatively large amount of data for the vertical component which are tabulated in comparison 7, table 39.

At distances between 200 and 300 kilometers and 600 and 800 kilometers, periods of 0.5 and 0.6 second prevail very clearly in the vertical component with frequencies of 42 and 50 percent respectively. The corresponding values for all measurements are 41 percent and 21 percent so that here again the periods of 0.5 and 0.6 second are more frequently recorded in the vertical component than in the horizontal components. On the other hand, the average frequency of periods of 1.0 to 1.2 seconds in the P-phase is 36 percent for all measurements for distances between 600 and 800 kilometers, but only 7 percent for the vertical component. Similar results are to be found for the S-phase, where again the periods of 0.5 and 0.6 second have been observed with a higher frequency in the vertical component than in the horizontal, while the latter shows very much more frequently periods between 1.0 and 1.2 seconds. In the M-phase, again, the observed number of periods in the neighborhood of 0.6 second is somewhat larger in the vertical component, but in this case periods of 1.0 and 1.2 seconds are shown quite frequently too—the frequency being 28 percent for distances between 600 and 800 kilometers in the vertical component and 32 percent for all measurements.

For Tinemaha we have again the special measurements for local shocks at distances less than 50 kilometers. They do not show large differences between the horizontal and the vertical components, as may be seen from comparison 8, table 39.

For distances between 100 and 200 kilometers, between 60 and 70 observations are available for the vertical component. The results derived from the measurements are shown in comparison 9, table 39. Here short periods again prevail more clearly in the vertical than in the horizontal components.

At large distances the frequency of periods of 0.5 and 0.6 second is about the same in the vertical and horizontal component in all phases, except that at distances between 600 and 800 kilometers these periods have been observed somewhat more frequently in the vertical component than in the horizontal, as shown in comparison 10, table 39. Again, periods in the neighborhood of 1 to 1.2 seconds are more frequently recorded in the horizontal component than in the vertical. At distances between 600 and 800 kilometers, the P-phase shows these periods in only 7 percent of the observations for the vertical component, while the corresponding figure for all measurements together is over 25 percent. In the S-phase at the same distance the vertical component has these periods in 8 percent of the observations while all measurements give 25 percent, but in the M-phase they have been observed in 25 percent of the cases in the vertical component which equals within the limits of error the 25 percent of observations of these periods in all measurements.

If we finally summarize the results of this section, we see that the vertical components show more clearly the dominant short periods than do the horizontal components, but the latter indicate a larger number of waves with periods of 1.0 to 1.2 seconds. It is not possible to determine how much this result is influenced by the constants of the instruments, but it is not impossible that the vertical component of the ground movement really contains the dominant periods, especially those which are below 1 second, somewhat more frequently than the horizontal components.

THE EFFECT OF DISTANCE ON THE RECORDED PERIODS

In order to get the mean change of period with distance, all readings have been separated into groups with distances of 0 to 50, 51 to 100, 101 to 200, etc., kilometers for each station and for each phase. The results are given in tables 40 to 47 with the prevailing periods printed in heavy figures. In table 48 the prevailing periods are listed for each station and each distance. These tables show very clearly two facts: The first is that the range of periods prevailing in records belonging to a certain distance is very narrow, and differs from station to station only at the shorter distances. The second is that certain periods, especially those in the neighborhood of 0.5 to 0.6 second and from 1.0 to 1.2 seconds, prevail at certain distances at all stations. These facts are of high importance to structural engineers, as the data show the range of periods which prevail at a certain locality and for this reason are most dangerous to buildings there. Therefore, buildings should not have free periods in that range. The second result makes it very clear that at all seven stations the ground showed much more frequently waves with periods of 0.5 and 1.0 to 1.1 seconds than it should in case of forced vibrations. These periods correspond very probably to free vibrations of the ground at all stations.

TABLE 40.—*Frequencies of different periods recorded at Pasadena during earthquakes originating at different ranges of distance*

PASADENA P-PHASE, LONG PERIOD INSTRUMENTS

Distance (km)	Periods in seconds																			
	0.1 to 0.2	0.3 to 0.4	0.5 to 0.6	0.7 to 0.8	0.9 to 1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	**79**	**71**	31	16	3	7		3			2									
51 to 100	29	**120**	94	29	2															
101 to 200	72	117	**170**	22	20	4	1	2												
201 to 300	6	48	**157**	59	69	16	23	16	11	6	1		1							
301 to 400	4	11	**15**	6	5															
401 to 600	2	22	66	**83**	**79**	68	62	64	49	49	9	17	6	3	1	3	2	1		
601 to 800			1	3	**7**	2	2	5	3	1	1		3	2	2					
801 to 1,000	3	5	21	22	**48**	36	21	21	7	**26**	15	9	7	13	10	9	2			
1,001 to 1,500		2	8	6	1			3	5	**10**	**4**	**12**	7	4	4	8				
2, 001 to 2,500					5	1	1	7		22	9	**33**	**23**	**26**	**31**	20	4	1		
Total	195	396	**563**	246	239	134	110	**119**	75	**112**	38	71	47	48	48	40	8	2		

PASADENA S-PHASE, LONG PERIOD INSTRUMENTS

Distance (km)	0.1 to 0.2	0.3 to 0.4	0.5 to 0.6	0.7 to 0.8	0.9 to 1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	46	**82**	54	26	8	15	4	1	6	2	2									
51 to 100	19	63	**92**	53	22	6	1	1	1	2			1	1	3	1		1		
101 to 200	50	92	**142**	60	42	9	6	3		2										
201 to 300	9	18	**91**	52	77	41	29	27	13	10	11		1							
301 to 400		10	12	12	**16**	4	3	1	2	2										
401 to 600		16	28	32	**61**	39	36	**58**	42	**72**	51	48	36	10	26	44	17			
601 to 800					2	1	4	**13**	1	2	2	1	2							
801 to 1,000	3	2	9	5	19	18	7	18	18	**31**	**23**	29	4	11	11	9	3			
1,001 to 1,500				3	4	1		2	6	5	8	7	6	1	3	8	6	1	1	
2,001 to 2,500										4		2	3	5	13	**61**	35	14	6	
Total	127	283	**428**	243	**251**	134	90	124	89	**132**	97	87	53	28	56	**123**	58	16	7	

TABLE 40.—*Frequencies of different periods recorded at Pasadena during earthquakes originating at different ranges of distance*—Continued

PASADENA M-PHASE, LONG PERIOD INSTRUMENTS

Distance (km)	Periods in seconds																			
	0.1 to 0.2	0.3 to 0.4	0.5 to 0.6	0.7 to 0.8	0 9 to 1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	22	40	**67**	50	20	21	5	3	12	8	17	16	3							
51 to 100	9	14	37	51	**87**	36	17	13		8	6	3	1		2	2				
101 to 200	32	60	**96**	44	44	19	16	18	8	7	4	2								
201 to 300		3	**59**	**48**	**54**	47	33	31	16	24	21	11	7	3	20	1				
301 to 400		2	·1	4	**17**	1	3	1	5	8	1									
401 to 600		5	6	13	**57**	28	30	41	21	**57**	43	38	49	22	**87**	76	5			
601 to 800					2	1	1	2		2	2	3	**7**	2	6					
801 to 1,000					4	3	1	5	5	11	8	10	16	4	26	**108**	49	3		
1, 001 to 1,500						1	5	2	6	1	2	7	6	1	4	4	**13**		**11**	
2,001 to 2,500															1	3	27	40	**62**	7
Total	63	124	**266**	210	285	154	111	116	77	**126**	104	90	89	32	120	194	94	43	73	**7**

TABLE 41.—*Frequencies of different periods recorded at Pasadena during earthquakes originating at different ranges of distance*

PASADENA P-PHASE, SHORT PERIOD INSTRUMENTS

Distance (km)	Periods in seconds																								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	11	**91**	**85**	38	52	18	4	3	1	2															
51 to 100	27	62	75	**115**	**127**	37	5	3	2		1														
101 to 200	40	70	86	**106**	**148**	56	12	2																	
201 to 300	8	34	41	58	**120**	**103**	84	59	25	40	13	14	12	3	5	9	4	1		2					
301 to 400	1	9	9	10	**19**	**14**	3			2															
401 to 600	13	38	40	48	**111**	**98**	94	77	74	**98**	65	16	8	2	2	1	2	1							
601 to 800					2	2	5	3	5	**11**	**13**	5	3												
801 to 1,000	1	12	14	1	8	16	32	27	34	**93**	**91**	26	31	7	9	2	3								
1,001 to 1,500					3	8	13	3		**12**	**15**	8	11	5	11	3	6	2							
2,001 to 2,500							1		2	7	3	2	9	1	**25**	17	**27**	17	6	11	6	3			
Total	101	316	350	381	**590**	352	253	177	147	**265**	200	71	74	18	**52**	32	42	21	6	13	6	3			

PASADENA S-PHASE, SHORT PERIOD INSTRUMENTS

Distance (km)	Periods in seconds																								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	7	53	**76**	49	61	43	21	8	2	1															
51 to 100	4	16	31	67	**122**	91	45	20	8	8															
101 to 200	60	71	57	82	**128**	72	20	13	9	6	2														
201 to 300	2	8	8	29	**86**	**92**	69	58	35	**51**	32	25	19	12	12	5	1								
301 to 400		3	11	12	**16**	12	8	5	6																
401 to 600	3	12	14	26	68	**101**	69	68	83	**100**	85	35	30	14	19	4	1								
601 to 800					1	1	1		5	9	**11**	4	8	2	3	1				1	2				
801 to 1,000		7	10	6	6	5	9	10	17	43	**71**	37	**62**	28	26	22	16	8	1	1	1				
1,001 to 1,500						1			3	7	10	8	**12**	10	6	7	12	7	1	1	1				
2,001 to 2,500											2		2		1	2	4	10	8	7	27	14	11	2	
Total	76	170	207	271	488	**418**	242	182	168	**225**	213	109	133	66	67	41	34	25	10	12	35	14	11	2	

PASADENA M-PHASE, SHORT PERIOD INSTRUMENTS

Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	8	28	21	33	**62**	54	53	38	19	21	15	5													
51 to 100	8	9	6	24	69	**91**	56	69	39	25	9														
101 to 200	25	54	49	62	**109**	**73**	39	28	11	15	9		1												
201 to 300	2	2	1	6	33	48	46	**59**	52	**72**	48	45	30	19	10	15	6	6	4	7	1				
301 to 400		6	9	**12**	**11**	7	8	**10**	5	7	2														
401 to 600	3	2	1	2	24	36	45	52	**93**	**110**	**105**	54	83	18	25	14	18	13	5	1					
601 to 800										1		1	3	1	5		2	7	1	1	**12**	3			
801 to 1,000						3		1	3	14	17	10	26	16	18	14	28	15	8	28	**115**	43	3		
1,001 to 1,500										4	3		7	4	6	6	8	2	5	3	7	6	3	**12**	
2,001 to 2,500																						14	**37**	30	5
Total	46	101	87	139	**308**	**312**	247	257	222	**269**	208	115	150	58	59	49	62	43	23	40	**135**	66	43	42	5

TABLE 42.—*Frequencies of different periods recorded at Riverside during earthquakes originating at different ranges of distance*

RIVERSIDE P-PHASE

Distance (km)	Periods in seconds																						
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 and more
0 to 50	**12**	5	2	1																			
51 to 100	**265**	**196**	118	67	35	15	1	9			4		2	2									
101 to 200	22	64	**89**	**84**	**100**	53	13	8	2														
201 to 300	4	7	16	**22**	**28**	14	6	3	2	3	1	2	1										
301 to 400	2	10	25	26	**46**	36	30	13	8	12	5	2	2	3									
401 to 600	5	13	19	39	**82**	50	56	47	41	45	39	13	20	6	2								
601 to 800				3	3	1	4	3	7	5	**20**	10	6	3	5	1							
801 to 1,000					7	8	13	7	12	**34**	26	18	10	7	6								
1,001 to 1,500			4	3	2	4	8	1	7	**13**	6	12	14	2	2								
1,501 to 2,000								1	1	2					**4**	3	2	2	1	3	3		
2,001 to 2,500							1	1	4	7	11	13	15	**28**	**27**	**26**	9	2	3	3			
Total	**310**	**295**	273	245	**303**	181	132	93	84	**121**	112	70	70	51	46	30	11	4	4	6	3		

RIVERSIDE S-PHASE

Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 and more
0 to 50	**6**	**8**	**8**	4	2	1																	
51 to 100	149	**302**	151	38	24	14	16	6	6	8	3	2	2	1									
101 to 200	37	60	64	51	**92**	34	13	6	5	7	3	2	2	1									
201 to 300	4	16	20	20	**47**	**41**	17	6	5	3	2	2	2										
301 to 400	4	1	6	16	**45**	**41**	21	15	8	19	12	7	5	5	5	3							
401 to 600		5	5	14	**54**	**57**	**46**	**47**	**42**	**42**	**40**	20	18	17	16	9							
601 to 800					1	5	9	4	4	5	**13**	9	5	5	3	1							
801 to 1,000			4	2						5	13	6	17	11	**20**	14	8	4	1	1	5	1	
1,001 to 1,500			2	1	6	2	1	1	2	3	2	4	5	**7**	8	**9**	2	3	1			1	3
1,501 to 2,000														3	3	5	**8**						
2,001 to 2,500		1	1		1	2	2	4			2		1	3	4	3	2	17	11	10	30	32	2
Total	200	**393**	261	146	**272**	197	125	89	72	**92**	90	52	57	53	59	44	20	24	13	11	35	34	5

RIVERSIDE M-PHASE

0 to 50	**10**	**14**	4	6	13	7	-----	6	5	7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
51 to 100	98	**209**	112	70	64	49	29	18	29	27	18	19	19	8	2	4	3	-----	-----	-----	-----	-----	-----
101 to 200	16	**52**	45	44	**70**	**63**	47	31	16	15	7	6	7	5	6	1	2	2	-----	1	-----	-----	-----
201 to 300	-----	1	5	11	**23**	**17**	10	5	3	4	2	1	3	3	-----	-----	-----	-----	-----	-----	-----	-----	-----
301 to 400	3	3	3	5	13	18	18	19	24	**37**	22	20	12	7	7	1	2	-----	-----	-----	-----	-----	-----
401 to 600	-----	2	5	13	16	26	20	28	43	**58**	34	32	24	27	34	16	9	2	5	-----	-----	-----	-----
601 to 800	-----	-----	-----	-----	-----	3	3	1	3	3	5	**9**	7	5	4	2	2	-----	-----	2	3	4	**6**
801 to 1,000	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	1	-----	7	2	**10**	8	1	8	13	**22**	16	3	2
1,001 to 1,500	-----	-----	-----	-----	-----	-----	-----	1	1	-----	1	2	3	4	**13**	7	5	5	-----	1	2	2	**17**
1,501 to 2,000	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	1	1	1	-----	-----	-----	2	-----	-----	-----	-----	-----	**15**
2,001 to 2,500	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	4	9	-----	2	10	2	6	**63**
Total	127	**281**	174	149	**199**	**184**	127	109	124	**153**	91	90	83	61	**78**	43	35	17	20	36	23	15	**103**

TABLE 43.—*Frequencies of different periods recorded at Mount Wilson during earthquakes originating at different ranges of distance*

MOUNT WILSON P-PHASE

Distance (km)	Periods in seconds																						
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.	15.5 to 20.4
0 to 50	15	**114**	57	19	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
51 to 100	96	**237**	130	44	22	7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
101 to 200	30	65	**83**	51	43	9	5	3	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
201 to 300	8	54	**78**	**77**	**73**	32	7	15	10	19	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
301 to 400	-----	2	6	9	**16**	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
401 to 600	1	29	39	71	**148**	111	34	26	26	21	21	5	6	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
601 to 800	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
801 to 1,000	-----	-----	-----	12	15	15	23	22	11	**61**	**32**	9	10	2	1	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
1,001 to 1,500	-----	-----	-----	-----	3	5	7	6	3	6	10	5	**12**	6	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
2,001 to 2,500	-----	-----	-----	1	1	-----	3	2	1	14	17	8	13	11	27	23	**29**	**33**	5	1	-----	-----	-----	-----	-----
Total	160	**501**	393	284	**327**	185	76	74	52	**121**	84	27	41	20	29	24	29	33	5	1	-----	-----	-----	-----	-----

TABLE 43.—*Frequencies of different periods recorded at Mount Wilson during earthquakes originating at different ranges of distance*—Cont.

MOUNT WILSON S-PHASE

Distance (km)	Periods in seconds																								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	17	**75**	82	27	31	3		3																	
51 to 100	25	**170**	**188**	81	35	12				1															
101 to 200	33	46	**60**	**61**	**61**	21	7	3	3	2															
201 to 300	1	17	**47**	30	**86**	53	30	20	11	34	18	11	9	2	1	2	2	1							
301 to 400		4	2	6	**16**	8																			
401 to 600	3	3	9	29	85	**109**	66	54	38	36	23	7	27	8	4	3	4								
601 to 800																									
801 to 1,000				5	17	10	9	8	12	36	**55**	16	18	9	8	2	9	2							
1,001 to 1,500							1			2	2	2	6	5	8	**7**	8	**7**					1	4	3
2,001 to 2,500										2			1	1	4	4	10	20	14	27	**60**	19	1		
Total	79	315	**388**	239	**331**	216	113	88	64	113	98	36	61	25	25	18	33	30	14	27	60	19	2	4	3

MOUNT WILSON M-PHASE

Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	8	**73**	**63**	32	39	21	6	7	1	7	5	4	4												
51 to 100	19	106	**138**	76	63	26	16	5	23	14	6		1												
101 to 200	8	34	54	57	**77**	40	12	10	4	3	2														
201 to 300		9	23	10	**39**	**43**	29	25	24	52	32	17	16	11	11	2	6	4	4						
301 to 400				2	8	**12**	8	4	6	6															
401 to 600		5	6	12	40	**60**	**54**	**47**	**61**	**57**	**60**	**53**	28	9	5		3	2	1	1					
601 to 800																									
801 to 1,000								1	3	11	**18**	**18**	**21**	11	**21**	10	15	5	9	15	**21**	**22**			
1,001 to 1,500										2			4	5	3	**7**	4	4	2				7	**14**	
2,001 to 2,500														3	2		6	5	6	5	27	**55**	43	10	6
Total	35	227	**284**	189	**266**	202	125	98	122	**152**	123	92	74	39	42	19	34	20	22	21	48	**77**	50	24	6

TABLE 44.—*Frequencies of different periods recorded at Santa Barbara during earthquakes originating at different ranges of distance*

SANTA BARBARA P-PHASE

Distance (km)	Periods in seconds																								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	8	**14**	8	3	6	1																			
51 to 100	3	**18**	3	8	3																				
101 to 200	6	30	75	176	**342**	155	61	22	9	12	5														
201 to 300		9	22	29	**69**	40	13	7	2	1															
301 to 400	2	14	29	29	**40**	27	16	4	2																
401 to 600		15	72	70	127	**141**	120	79	54	43	11						2								
601 to 800			1	6	**11**	5	2																		
801 to 1,000		2		8	2		2	3	7	**15**	2	2	1												
1,001 to 1,500					3	12	29	20	18	**42**	26	11	4	2	5		2	4							
1,501 to 2,000					2	2	1	1	3	**6**	1	2	1												
2,001 to 2,500					1	5	5	5	**13**	9	7	11	9	7	16	4	**26**	8	6						
Total	19	102	210	329	**686**	388	249	141	108	**128**	52	26	15	9	21	4	**30**	12	6						

SANTA BARBARA S-PHASE

Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50	3	5	6	4	**9**	6	3	2	1																
51 to 100	3	**8**	**7**	2	3	3	2	3																	
101 to 200	10	26	32	93	**255**	**235**	86	38	17	25	1	4	2												
201 to 300		4	8	17	27	**55**	37	24	8	12	8														
301 to 400			12	8	**33**	**30**	26	22	8	4	6														
401 to 600			34	23	76	91	**103**	91	92	**112**	65	25	22	7	9	3									
601 to 800					2	3		1	2	2	3			2	3	2	**5**								
801 to 1,000			1		1	2		1	1	5	3		3	9	3	2	1	1							
1,001 to 1,500			1		5	7	15	11	9	**24**	18	8	8	4	10	7	10	5	1	1	6			12	5
1,501 to 2,000									1	2	4	2	2	2	3		2	1							
2,001 to 2,500							1	2	1	1	2	1	4		4	5	6	17	17	21	**40**	6			
Total	16	43	101	147	411	**432**	273	195	140	**187**	110	40	41	24	32	19	24	24	18	22	46	6		12	5

TABLE 44.—*Frequencies of different periods recorded at Santa Barbara during earthquakes originating at different ranges of distance*—Contd.

SANTA BARBARA M-PHASE

Distance (km)	Periods in seconds																								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50					2	6	5	4	**11**	**10**	6														
51 to 100	3	6	4	2	5		6	3	4	3															
101 to 200		8	19	23	161	**182**	172	125	75	52	34	8	6	1	2	1									
201 to 300		2	10	16	**45**	**46**	21	25	20	17	9														
301 to 400		1	1	3	13	10	19	24	**26**	24	14	3	3												
401 to 600		1	22	10	34	43	61	**103**	79	**102**	**105**	59	46	17	21	7	3								
601 to 800															3	5	**7**	**7**							
801 to 1,000											1		1	6	3	4		1	1	1	**10**	8	**12**		
1,001 to 1,500							1	3	4	8	9	5	12	8	10	18	**23**	14	4	2	2	2	1		
1,501 to 2,000																2	8	4	2						
2,001 to 2,500																	4	8	1	1	6	28	26	**37**	2
Total	3	18	56	54	**260**	**287**	**285**	**287**	219	216	178	75	68	32	39	37	45	34	8	4	18	38	39	37	2

TABLE 45.—*Frequencies of different periods recorded at Haiwee during earthquakes originating at different ranges of distance*

HAIWEE P-PHASE

Distance (km)	Periods in seconds																							
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4
0 to 50 [1]	20	**35**	26	6	4																			
51 to 100	2	6	6	**7**	**7**																			
101 to 200	5	23	36	**37**	**42**	19	2	2		2														
201 to 300		44	81	107	**328**	**285**	183	116	78	85	104	64	21		1	2								
301 to 400			1	4	**15**	**10**	6	10	4	7	10	1	1											
401 to 600			9	25	**70**	**43**	19	24	25	33	18	6	3											
601 to 800			1	6	22	24	29	22	13	**39**	**43**	12	7	5	3	1								
801 to 1,000									1	7	8	4	7	2	2	1	1	1						

1,001 to 1,500			1	1	6	3	2	2	3	15	**23**	16	8	3										
1,501 to 2,000											6	1	1	5	6	4	4	1						
2,001 to 2,500							3	2	3	8	3	3	2	1	2	4	9	6						
Total	7	73	132	187	**490**	394	244	178	127	**196**	**215**	104	50	16	14	12	14	8						

HAIWEE S-PHASE

0 to 50[1]	12	**35**	**38**	14	**21**	1	1																	
51 to 100	1	5	3	6	**10**	4																		
101 to 200		12	20	23	**47**	**41**	20	15	2	1														
201 to 300		11	47	70	**271**	**268**	199	159	118	101	124	63	36	8	2									
301 to 400		3	3	1	4	3	4	6	6	7	**12**	9	2	5										
401 to 600				11	**53**	34	18	17	23	**35**	**37**	12	12											
601 to 800					16	**31**	**32**	21	19	**33**	**34**	12	6	4	3	4	3							
801 to 1,000											4	3	**5**	1	3	3	1				2	1	3	1
1,001 to 1,500									3	9	13	5	**17**	10	6	4	1					2	4	
1,501 to 2,000															2		4	3	2	3	**7**	3	1	
2,001 to 2,500																	1	6	5	**11**	**10**	8	1	2
Total	1	31	73	111	**401**	**381**	273	218	171	**186**	**224**	104	78	28	16	11	10	9	7	14	19	14	9	3

HAIWEE M-PHASE

0 to 50[1]	2	11	**19**	16	**24**	2	3	1																
51 to 100		2	3	6	**9**	4	3	1	2															
101 to 200		2	20	14	**42**	**36**	24	7	7	10	5	3												
201 to 300	2	10	28	31	139	**176**	**193**	156	132	**226**	189	94	56	17	5	1								
301 to 400				1	4	6	**12**	8	3	2	4	1												
401 to 600				5	25	16	17	16	20	**48**	**49**	14	19	4	5	4	1							
601 to 800					6	6	12	15	9	**33**	**35**	16	27	9	5	3	5	3		8	17	6		
801 to 1,000										2		3	3	2	3		1		1	1	**9**	5		
1,001 to 1,500													6	6	10	4	3	1	1		11	**14**	**13**	2
1,501 to 2,000																					3	5	**11**	8
2,001 to 2,500																	2	4	1		3	7	**13**	**11**
Total	2	14	51	57	**225**	**244**	**241**	203	173	**321**	**282**	131	111	38	28	12	12	8	3	9	43	37	37	21

[1] From records of shocks not listed in table 29. These figures are not included in the total.

TABLE 46.—*Frequencies of different periods recorded at Tinemaha during earthquakes originating at different ranges of distance*

TINEMAHA P-PHASE

Distance (km)	Periods in seconds																							
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4
0 to 50 [1]	23	**41**	32	17	12	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
51 to 100	----	16	**18**	14	15	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
101 to 200	5	48	58	68	**123**	84	48	23	15	7	3	----	----	----	----	----	----	----	----	----	----	----	----	----
201 to 300	2	10	49	42	**113**	56	25	12	8	11	24	18	6	4	----	----	----	----	----	----	----	----	----	----
301 to 400	4	38	81	101	**283**	165	89	29	8	11	3	3	6	----	----	----	----	----	----	----	----	----	----	----
401 to 600	----	2	5	15	**64**	52	37	28	16	20	11	----	----	----	----	----	----	----	----	----	----	----	----	----
601 to 800	----	----	3	6	22	**34**	**35**	22	16	**29**	22	7	6	----	1	----	----	----	----	----	----	----	----	----
801 to 1,000	----	----	----	3	**4**	2	1	2	----	1	----	----	1	----	**4**	**3**	**4**	----	----	----	----	----	----	----
1,001 to 1,500	----	----	----	----	1	4	3	1	3	11	**18**	**10**	**17**	4	4	4	4	5	----	----	----	----	----	----
1,501 to 2,000	----	----	----	----	----	----	4	----	----	7	6	5	6	3	**10**	1	4	1	----	----	----	----	----	----
2,501 to 3,000	----	----	----	----	----	----	1	5	2	7	2	1	3	3	5	4	**21**	13	10	1	----	----	----	----
Total	11	114	214	249	**625**	397	243	122	66	**104**	89	44	45	14	24	12	33	19	10	1	----	----	----	----

TINEMAHA S-PHASE

Distance (km)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4
0 to 50 [1]	5	21	34	44	**82**	7	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
51 to 100	2	6	7	12	**21**	15	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
101 to 200	----	25	22	51	**78**	**79**	57	41	20	31	24	8	6	4	----	----	----	----	----	----	----	----	----	----
201 to 300	9	17	24	32	**77**	57	45	37	28	28	31	11	5	----	----	----	----	----	----	----	----	----	----	----
301 to 400	----	2	23	36	**193**	**209**	164	64	24	23	13	9	3	----	2	1	2	----	----	----	----	----	----	----
401 to 600	----	----	----	2	18	28	29	27	24	**56**	30	17	9	1	3	----	1	----	----	----	----	----	----	----
601 to 800	----	----	----	5	**32**	**30**	23	16	11	**29**	17	7	10	5	4	1	3	3	2	----	----	----	----	----
801 to 1,000	----	----	----	----	----	----	----	1	1	----	----	----	2	----	**6**	**5**	4	2	----	----	----	----	----	----
1,001 to 1,500	----	----	----	----	1	2	----	----	1	8	1	3	**13**	**9**	**13**	**12**	10	5	3	3	1	----	----	----
1,501 to 2,000	----	----	----	----	----	----	----	----	----	----	----	----	1	4	3	3	**8**	6	3	**9**	2	----	2	----
2,501 to 3,000	----	----	----	----	----	----	----	----	----	----	----	----	----	----	4	1	**16**	**17**	15	9	**17**	----	----	----
Total	11	50	76	138	**420**	**420**	322	186	109	**175**	116	55	49	23	35	23	44	33	23	21	20	----	2	----

TINEMAHA M-PHASE

0 to 50[1]		2	7	19	**54**	34	7	4	1	2														
51 to 100		5	5	2	6	8	4	5	10	**16**	4	2												
101 to 200		8	23	24	54	**59**	50	44	40	43	**49**	22	26	11	10	1	7	9	3	1				
201 to 300		4	11	30	**70**	42	41	30	24	31	20	21	17	7	7	3	3		1					
301 to 400	2	8	20	20	109	168	**191**	94	59	39	18	11	6	1	7	4		4	1	2				
401 to 600			2	2	14	17	23	22	21	**36**	17	12	17	11	8	2	3	1	2					
601 to 800					6	6	12	14	7	**27**	19	21	24	13	9	10	10	10	4	4				
801 to 1,000													1		5	3	**8**			1				
1,001 to 1,500												1	2	3	**14**	**13**	10	10	3	3	8	9	8	
1,501 to 2,000														1	1	2	2	1	1		1	4	**15**	6
2,501 to 3,000																	4	6	2	4	**22**	**19**	8	8
Total	2	25	61	78	259	**300**	**321**	209	161	192	127	90	93	47	61	38	47	41	17	15	31	32	31	14

[1] From records of shocks not listed in table 29. These figures are not included in the total.

TABLE 47.—*Frequencies of different periods recorded at La Jolla during earthquakes originating at different ranges of distance*

LA JOLLA P-PHASE

Distance (km)	Periods in seconds																							
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50[1]	8	**19**	**15**	3																					
51 to 100	4	**7**		8	6																				
101 to 200	40	153	**222**	**204**	128	40	11		1	5	7		1												
201 to 300		4	9	**13**	**20**	3	1																		
301 to 400	3	9	16	20	**36**	18	3	2	3	1															
401 to 600		8	39	30	**44**	12	9	8	10	12	11	3													
601 to 800		2	13	10	34	33	57	82	61	**131**	**153**	52	48	10	10	12	1	2	1						
801 to 1,000						1	2			**7**	**7**	4	3	2	1	1									
1,001 to 1,500				3		14	28	34	19	**44**	34	6	6	6	11	2	2	2	2						
2,001 to 2,500								3	2	11	5	9	16	6	15	**26**	17	13	2	4					
Total	47	183	**299**	**288**	**268**	121	111	129	96	**211**	**217**	74	73	24	37	41	20	17	5	4					

TABLE 47.—*Frequencies of different periods recorded at La Jolla during earthquakes originating at different ranges of distance*—Continued

LA JOLLA S-PHASE

Distance (km)	Periods in seconds																							
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	1.7 to 1.8	1.9 to 2.0	2.1 to 2.4	2.5 to 2.8	2.9 to 3.2	3.3 to 3.6	3.7 to 4.4	4.5 to 6.4	6.5 to 8.4	8.5 to 10.4	10.5 to 15.4	15.5 to 20.4
0 to 50[1]	2	11	**17**	9	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
51 to 100	----	----	2	**9**	**8**	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
101 to 200	24	81	1[illegible]0	**172**	**182**	87	34	13	10	1	3	1	----	----	----	----	----	----	----	----	----	----	----	----	----
201 to 300	----	3	7	9	**24**	12	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
301 to 400	----	1	1	16	**39**	26	8	4	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
401 to 600	----	1	17	12	**30**	**26**	**27**	23	11	21	7	3	1	1	1	----	----	----	----	----	----	----	----	----	----
601 to 800	----	----	3	----	11	27	42	50	55	94	**124**	82	103	31	26	19	12	1	----	----	3	----	----	----	----
801 to 1,000	----	----	----	----	----	----	----	----	----	----	3	----	6	**8**	3	3	1	----	----	----	----	2	----	----	----
1,001 to 1,500	----	----	----	----	1	3	13	13	7	35	**50**	13	15	9	16	13	20	5	3	1	----	----	----	----	----
2,001 to 2,500	----	----	----	----	----	----	----	----	1	1	1	----	3	6	11	**20**	8	11	12	15	**22**	5	3	----	----
Total	24	86	170	218	**295**	182	127	103	85	**152**	**188**	99	128	55	57	55	41	17	15	16	25	7	3	----	----

LA JOLLA M-PHASE

0 to 50[1]	----	8	**12**	9	6	3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
51 to 100	----	3	3	**7**	6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
101 to 200	9	14	43	86	**205**	155	118	85	35	22	7	3	2	2	1	----	----	----	----	----	----	----	----	----	----
201 to 300	----	4	5	8	**14**	**12**	3	2	2	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
301 to 400	----	1	3	3	**12**	6	5	10	10	**13**	5	7	----	----	----	----	----	----	----	----	----	----	----	----	----
401 to 600	----	----	6	4	9	15	19	18	14	**30**	13	6	4	4	10	5	5	1	----	----	----	----	----	----	----
601 to 800	1	6	1	2	10	16	24	34	29	62	**127**	65	95	53	53	54	41	16	9	4	4	----	----	----	----
801 to 1,000	----	----	----	----	----	----	----	----	----	----	3	2	**5**	**4**	**4**	----	----	----	----	----	3	4	2	----	----
1,001 to 1,500	----	----	----	----	----	----	3	1	4	**19**	16	8	18	10	19	24	**28**	8	1	2	20	6	10	4	2
2,000 to 2,500	----	----	----	----	----	----	----	----	----	----	----	----	1	1	3	----	7	----	----	2	9	27	13	**34**	8
Total	10	28	61	110	**256**	204	172	150	94	**148**	**171**	91	125	74	90	83	81	25	10	8	36	37	25	38	10

[1] From records of shocks not listed in table 29. These figures are not included in the total.

TABLE 48.—*Prevailing periods*

Station	Distance in kilometers										
	0 to 50	51 to 100	101 to 200	201 to 300	301 to 400	401 to 600	601 to 800	801 to 1,000	1,001 to 1,500	1,501 to 2.500	≧2,501
P-PHASE											
	Seconds	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
Pasadena, long	0. 2-0. 4	0. 4	0. 6	0. 6	0. 6	0. 8-1. 0	1. 0	1. 0	2. 0	----------	2. 5-5. 0
Pasadena, short	0. 2-0. 3	0. 4-0. 5	0-4-0. 5	0. 5-0. 6	0. 5-0. 6	0. 5-0. 6	1. 0-1. 2	1. 0-1. 2	1. 1	----------	2. 2
Mount Wilson	0. 2	0. 2	0. 3	0. 3-0. 5	0. 5	0. 5	----------	1. 0-1. 1	1. 5	----------	3
Riverside	0. 1	0. 1-0. 2	0. 3-0. 5	0. 4-0. 5	0. 5	0. 5	1. 1	1. 0-1. 1	1. 0	2	2
La Jolla	[1] 0. 2-0. 3	0.2; 0. 4	0. 3-0. 4	0. 4-0. 5	0. 5	0. 5	1. 0-1. 2	1. 0-1. 2	1. 0-1. 1	----------	2. 2
Santa Barbara	0. 2	0. 2	0. 5	0. 5	0. 5	0. 6	0. 5	1. 0	1. 0	1. 0	0.9; 2. 8
Tinemaha	[1] 0. 2-0. 3	0. 2-0. 5	0. 5	0. 5	0. 5	0. 5	0. 6-0.7; 1. 0	(0.5); 2-2. 5	1-1. 5	2	3
Haiwee	[1] 0. 2	0. 2-0. 5	0. 3-0. 5	0. 5-0. 6	0. 5-0. 6	0. 5-0. 6	0.7; 1. 0-1. 2	1. 0-1. 2	1. 1	(2)	1-2. 8
S-PHASE											
Pasadena, long	0. 4	0. 6	0. 6	0. 6	1. 0	2. 0	1. 5	2. 0	4. 0	----------	4. 0
Pasadena, short	0. 3	0. 5	0. 5	0. 5-0. 6	0. 5	0 6; 1. 0-1. 1	1. 1	1.1; 1. 5	1. 5	----------	3
Mount Wilson	0. 2-0. 3	0. 2-0. 3	0. 3-0. 5	0. 5	0. 5	0. 6	----------	1. 1	2	----------	5
Riverside	0. 1-0. 3	0. 2	0. 5	0. 5-0. 6	0. 5-0. 6	0. 5-1. 2	1. 2	1-2	2. 5	3	5
La Jolla	[1] 0. 3	0. 4-0. 5	0. 4-0. 5	0. 5	0. 5	0. 5-0. 7	1. 1	1. 7	1. 1	----------	2.2; 5
Santa Barbara	0. 5	0. 2-0. 3	0. 5-0. 6	0. 6	0. 5-0. 6	0.7; 1. 0	2. 8	1. 8	1. 0	(1. 1)	5
Tinemaha	[1] 0. 5	0. 5	0. 5-0. 6	0. 5	0. 5-0. 6	(0.6-0.7); 1. 0	0. 5-0.6; 1. 0	2	1. 5-2	(2.8; 4)	3; 5
Haiwee	[1] 0. 2-0. 3	0. 4-0. 5	0. 5-0. 6	0. 5-0. 6	1. 1	0.5; 1. 0-1. 2	0. 6-0. 7; 1.1-1. 2	1.5; (10)	1. 6	6	4-6
M-PHASE											
Pasadena, long	0. 6	1. 0	0. 6	0. 6; 1. 0	1. 0	1. 0; 2. 0; 4. 0	3. 0	5. 0	7; 12	----------	12
Pasadena, short	0. 5-0. 6	0. 6	0. 5-0. 6	0. 8; 1. 0	0. 4-0. 5	1. 0	5	5	(12)	----------	10
Mount Wilson	0. 2-0. 3	0. 3	0. 5	0. 5-0. 6	0. 6	0. 6-1. 2	----------	1-2; 5-8	12	----------	7-10
Riverside	0. 1-0. 2	0. 2	0. 2; 0. 5-0. 6	0. 5-0. 6	1. 0	1. 0	1. 0-1. 5	2	2; 8	8	8
La Jolla	[1] 0. 3	0. 4	0. 5	0. 5-0. 6	0. 5; 1. 0	1. 0	1. 0	1. 5-2	2-3	----------	12
Santa Barbara	0. 2; 0. 6; 0. 9	(0. 2); (0. 7)	0. 6-0. 7	0. 5-0. 6	0. 9	0. 8; 1. 0-1. 2	2. 5-3	4. 5-10	(2. 5)	2. 8	9-15
Tinemaha	[1] 0. 5	(0. 6); 1. 0	0. 6; 1. 1	0. 5	0. 6-0. 7	(0. 7-0. 9); 1. 0	1. 0; (1. 5)	(2. 8)	2	10	5-8
Haiwee	[1] 0. 3; 0. 5	0. 5	0. 5-0. 6	0. 6-0. 7; 1. 0	0. 7	1. 0-1. 2	1. 0-1. 2	6	5-10	10-12	10-12

[1] From records of shocks not listed in table 29.

We may therefore conclude either that these free periods are the fundamental period and its first harmonic (or two higher harmonics) of free vibrations of a layer which extends throughout the whole region under consideration, or that we have everywhere two single layers of different thickness, the period of 0.5 second indicating free vibrations of the thinner layer and the period of 1.1 seconds the free vibrations of the thicker layer.

It may be noticed, finally, that for periods less than 1.5 seconds there is no great difference between the tabulation for the short period instruments and the long period instruments at Pasadena.

THE EFFECT OF THE STATION

There is a distinct difference between the short periods prevailing at distances less than 50 kilometers at different stations. This should be attributed, therefore, to free vibrations of thinner layers which differ from station to station.

THE EFFECT OF THE EPICENTER ON THE RECORDED PERIODS

As may be seen from tables 32 to 38 there can be no large differences due to effects at the epicenter or the wave paths, as the periods measured from different shocks do not differ very widely if the distances are about the same. There are several possibilities for investigating the effect of the epicenter or wave path on the recorded periods. One would be to compare the numbers of periods measured in shocks from about the same distance but from epicenters in different directions. Another would be to compare the periods measured from a group of shocks originating in the same region with the average of all shocks originating at about that distance. The latter procedure must be used very carefully as the average of all shocks for a distance contains, of course, the shocks under consideration, and if they form a large percentage of these shocks the average will be affected considerably by the shocks under consideration.

Both methods were used in the following investigation. Ten regional groups of earthquakes were selected from those listed in table 30, as follows:

Group nos.	*General region*	*Earthquake nos.*
1	Mojave Desert	4 to 8, inclusive.
2	Parkfield	13, 22 to 25.
3	Santa Monica	10, 21, 28, 29.
4	Brawley	30 to 38.
5	Long Beach	56 to 75, 89.
6	Whittier	76 to 86.
7	Nevada, nearby	88 to 96, 108.
8	Nevada, distant	97 to 102.
9	San Bernardino Mountains	1 to 3.
10	Santa Barbara	14, 15, 107.

Comparisons of periods (1) between individual groups, and (2) between single groups and average values are shown in table 49. The more frequent periods are shown in bold face type. The following comments are made on the various tabulated comparisons, of which table 49 gives some examples:

33504—36——15

TABLE 49.—*Frequencies observed at various stations for selected regional groupings of earthquakes*

[The tabulated frequencies are expressed in percentage of the total number of periods measured in each horizontal group. Read text for comment on comparisons. The most frequent periods are shown in boldface type]

Comparison no.	Group no.	Observing stations and epicentral regions	Average or range of epicentral distances	Phase	Periods in seconds													
					0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	≧1.7
		RIVERSIDE	*km*															
1	1	Mojave Desert	75–146	M	8	**22**	23	**24**	16	6	1	0	0	0	0	0	0	0
		Various epicenters	101–200	M	4	12	10	10	**16**	**14**	11	7	4	3	2	1	2	4
		PASADENA																
2	1	Mojave Desert	117–173	M	1	18	19	19	**24**	13	3	3	1	0	0	0	0	0
		Various epicenters	101–200	M	5	11	10	13	**23**	15	8	6	2	3	2	0	0	0
		SANTA BARBARA																
3	1	Mojave Desert	245–300	M	0	1	10	12	**29**	23	10	7	6	1	0	0	0	0
		Various epicenters	201–300	M	0	1	5	8	21	**22**	10	**12**	10	8	4	0	0	0
		TINEMAHA																
4	1	Mojave Desert	235–300	M	0	2	3	13	**40**	14	14	8	4	4	0	0	0	0
		Various epicenters	201–300	M	0	1	3	8	**19**	12	11	8	7	9	6	6	5	4
		SANTA BARBARA																
5	2	Parkfield	168–179	S	0	2	9	9	**24**	15	12	11	4	12	0	2	0	0
		Various epicenters	101–200	S	1	3	4	11	**31**	**29**	11	4	2	3	0	1	0	0
6	2	Parkfield	168–179	M	0	0	2	3	**15**	12	12	12	10	**15**	9	3	4	3
		Various epicenters	101–200	M	0	1	2	3	**19**	**21**	**20**	14	8	6	4	1	1	0
		TINEMAHA																
7	2	Parkfield	235–350	M	0	1	3	5	**11**	7	7	9	9	**15**	11	7	6	9
		Various epicenters	201–300	M	0	1	3	8	**19**	12	11	8	7	**9**	6	6	5	5
		PASADENA																
8	3	Santa Monica	50	M	8	**12**	6	9	**26**	13	9	9	7	1	0	0	0	0
	5	Long Beach	60	M	2	2	1	5	17	**24**	14	17	10	7	2	0	0	0

TABLE 49.—*Frequencies observed at various stations for selected regional groupings of earthquakes*—Continued

[The tabulated frequencies are expressed in percentage of the total number of periods measured in each horizontal group. Read text for comment on comparisons. The most frequent periods are shown in boldface type]

Comparison no.	Group no.	Observing stations and epicentral regions	Average or range of epicentral distances	Phase	Periods in seconds: 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6	≧1.7
		MOUNT WILSON	*km*															
9	3	Santa Monica	55	M	4	9	14	**27**	**26**	6	7	4	1	1	0	0	0	0
	5	Long Beach	70	M	4	**24**	**30**	13	10	5	3	1	5	3	2	0	0	0
		SANTA BARBARA																
10	2	Parkfield	176	M	0	0	2	3	**15**	12	12	12	10	**15**	9	3	4	3
	5	Long Beach	182	M	0	1	0	0	13	**23**	**25**	20	11	5	3	0	0	0
		TINEMAHA																
11	3	Santa Monica	369	P	0	1	4	13	**44**	24	8	4	3	0	0	0	0	0
	5	Long Beach	379	P	0	5	11	12	**31**	21	11	4	0	2	1	1	1	0
12	3	Santa Monica	369	M	0	0	9	4	21	**27**	17	8	1	1	4	6	0	1
	5	Long Beach	379	M	0	2	1	3	13	22	**28**	13	9	5	2	0	1	1
		LA JOLLA																
13	3	Santa Monica	144	P	3	19	**24**	**22**	**30**	3	0	0	0	0	0	0	0	0
	6	Whittier	137	P	0	19	**24**	**20**	**22**	9	5	0	0	0	0	0	0	0
14	3	Santa Monica	144	M	8	4	10	18	**26**	16	13	2	1	2	0	0	0	0
	6	Whittier	137	M	0	3	17	15	**22**	15	15	5	5	4	0	0	0	0
		HAIWEE																
15	2	Parkfield	231	S	0	1	5	4	**25**	**22**	10	11	3	5	8	4	2	0
	3	Santa Monica	266	S	0	2	6	11	19	**48**	12	0	2	0	0	0	0	0
	5	Long Beach	275	S	0	1	3	6	**25**	**19**	14	9	8	7	6	2	1	0
	7	Nevada, nearby	250	S	0	1	2	4	**12**	**15**	**13**	**12**	9	8	11	8	4	1
	10	Santa Barbara	255	S	0	7	7	0	9	9	**23**	18	18	7	2	0	0	0
16	2	Parkfield	231	M	0	0	2	2	8	7	11	11	8	**23**	14	6	6	3
	3	Santa Monica	266	M	0	0	2	8	**23**	15	4	9	**15**	**15**	9	0	0	0
	5	Long Beach	275	M	0	0	1	2	13	**17**	14	11	9	**14**	10	5	2	1
	7	Nevada, nearby	250	M	0	0	1	1	7	10	**13**	12	9	**14**	16	8	5	3
	10	Santa Barbara	255	M	0	0	0	0	10	13	15	**21**	18	**21**	3	0	0	0

		TINEMAHA																
17	2	Parkfield	239	M	0	1	3	5	**11**	7	7	9	9	**15**	11	7	6	9
	8	Nevada, distant	203	M	0	0	0	0	4	**10**	7	7	9	12	**17**	15	12	8
		HAIWEE																
18	8	Nevada, distant	308	M	0	0	0	0	2	3	**11**	6	6	22	**27**	5	8	0
		Various epicenters	201–400	M	0	0	0	2	10	15	**29**	20	7	5	10	2	0	0
		RIVERSIDE																
19	5	Long Beach	70	M	11	**21**	10	7	8	8	5	4	6	5	4	4	4	3
	6	Whittier	58	M	13	**44**	25	9	6	2	1	0	0	0	0	0	0	0
	9	San Bernardino Mountains	50	M	11	**20**	7	12	**21**	10	0	7	6	8	0	0	0	0
		LA JOLLA																
20	9	San Bernardino Mountains	157	S	0	0	0	18	**42**	**32**	3	3	2	0	0	0	0	0
		Various epicenters	101–200	S	3	11	19	**23**	**24**	13	5	2	1	0	0	0	0	0

Group 1—(Comparisons 1 to 4).—Mojave Desert region. At most stations the periods measured are below average for all phases. Long periods are often missing.

Group 2—(Comparisons 5 to 7).—Parkfield region. The observed periods are in general slightly larger than the average corresponding to this distance. At Santa Barbara noticeably more periods of about 1.0 second are observed than in the average case, but fewer periods of 0.5 second. This illustrates well the fact, which we had found in investigating the effect of distance on the recorded periods, that usually the dominant periods change with the distance not gradually but in jumps, and that periods of about 0.5 and 1.0 second prevail. Results at Tinemaha show a similar effect.

Groups 3 and 4.—Santa Monica and Brawley. Earthquakes in the Santa Monica and Brawley areas have periods which everywhere correspond to about the average for the corresponding distances.

Group 5—(Comparisons 8 to 12).—The aftershocks of the Long Beach earthquake were so numerous that the average periods of all shocks, including those at other corresponding distances, are largely controlled by the periods of the aftershocks. No large differences can therefore be expected. In order to avoid spurious conclusions we compare in this case the shocks of one group with the shocks of another group originating at about the same distance from the station under consideration. The comparisons do not show any large differences.

Group 6—(Comparisons 13 and 14).—Whittier region. The observed periods correspond fairly closely to the average.

Group 7—(Comparisons 15 and 16).—Nearby shocks in Nevada. In general the periods agree about with the averages although the tabulations indicate slight differences.

Group 8—(Comparisons 17 and 18).—Distant shocks in Nevada. The Tinemaha records show about the same distribution of periods as the Parkfield shocks. Periods of about 1.1 seconds have been found very much more frequently at Haiwee than is usual at distances of 308 kilometers where periods of about 0.7 second prevail. This indicates again a jump in period as previously mentioned.

Group 9—(Comparisons 19 and 20).—San Bernardino Mountains. The periods are in general slightly longer than the average.

Group 10.—Santa Barbara region. The observed periods correspond to about the average.

As a whole we see that in most cases the effect of epicenter or wave path, which usually can hardly be separated, is relatively small. The differences may be explainable partly by differences in intensity in some cases. The periods from epicenters of a specific group may really differ somewhat from the average. The most interesting fact which we found is a confirmation of our previous result, that the periods prefer certain values and that the dominant periods jump if the distance passes a certain critical value. The periods observed less frequently correspond to the forced vibrations of the ground.

THE EFFECT OF MAGNITUDE OF THE SHOCK

In addition to the normal periods longer periods are observed usually in shocks where the original movement extends over a large area. Unfortunately, very little data are available in our material with which to investigate the effect of magnitude. The only region from which we have data concerning close-by shocks with different magnitudes is the Long Beach area. The main Long Beach shock was recorded clearly in detail in all phases at Pasadena only by the strong-motion instrument. The record shows, principally, waves with periods between 0.2 and 0.4 second riding on waves with longer periods—4 to 5 seconds and 8 to 10 seconds. There is no doubt that the short-period waves carried very much greater energy than the long-period waves so that they were really responsible for the damage. No waves with periods between 1.1 and a few seconds stand out in this record. Generally in the strong-motion records of the aftershocks only periods of a few seconds are recorded clearly, but on the records of the other instruments waves with periods of about 0.5 second are recorded frequently in the P- and S-phases while in the M-phase waves of about 1 second prevail. A comparison of the main shock with the aftershocks indicates, therefore, that both groups had about the same short periods, but that in the main shock there was, besides, a larger number of waves with periods of a few seconds which were very much less clear or missing in the aftershocks.

At La Jolla, Riverside, and Santa Barbara the records of the main shock do not show any details. At Haiwee (distance 276 kilometers) the periods observed during the main shock correspond approximately to those measured in the aftershocks except that the number of periods over 0.5 second which have been measured is relatively larger. The same is true concerning Tinemaha (distance 380 kilometers) where in the M-phase of the main shock, particularly, only periods of 1 second or more have been measured.

Similar phenomena, but less clear, have been found in other cases, so that it seems that longer periods beside the normal short periods are produced in strong shocks.

THE PERIODS OBSERVED IN BLASTS

The investigation of periods observed in blasts is of interest as it is possible to investigate the free periods in a certain region by blasting provided the periods so found correspond to those measured in earthquakes.

A list of blasts has been given in table 30. The distances in most cases have been taken from studies on the records of blasts in southern California by H. O. Wood and C. F. Richter.[1] The periods which have been measured in the records of the blasts are to be found in table 50. No blasts have been recorded at Tinemaha and Haiwee. Table 50 gives results similar to those found in the study of earthquakes except that the longer periods are less frequent. This agrees with our previous result that usually the longer periods are the more outstanding the larger the energy involved in the source. To produce waves with periods over 0.1 second, which are of interest to the engineer, a certain minimum of energy is needed, and, therefore, in most cases an explosion of e. g. 100 pounds of dynamite will not give an energy strong enough to investigate the frequencies of periods in the desired range. The short periods of 0.2 and 0.3 second are clearly prevailing at all stations, and the periods of 0.5 second and sometimes also 0.6 second show a clear maximum, especially in the S- and M-

[1] H. O. Wood and C. F. Richter, A Study of Blasting Recorded in Southern California (Bulletin of the Seismological Society of America, vol. 21, 1931, p. 28).
A Second Study of Blasting Recorded in Southern California (Bulletin of the Seismological Society of America, vol. 23, 1933, p. 95).

phases at large distances. A larger number of periods of about 1 second is indicated in the M-phase at Pasadena and Riverside. The long-period instruments at Pasadena show in each phase, in more than 70 percent of all cases, periods between 0.4 and 0.6 second. Only in the M-phase there is, besides, a slight maximum for periods around 1.0 second.

Table 50.—*Periods observed in blast records*

Station	Phase	Distance	Periods in seconds												
			0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4	1.5 to 1.6
		km													
Pasadena, short period	P	17–49	8	**63**	**53**	16	37	15	7	1	----	----	----	----	----
	P	67–98	----	23	**31**	15	15	5	1	----	----	----	----	----	----
	P	112	----	**10**	2	2	4	1	----	----	----	----	----	----	----
	S	17–49	3	36	**46**	30	**48**	34	14	8	5	5	4	----	----
	S	67–98	1	17	34	15	16	4	1	----	----	----	----	----	----
	S	112	----	6	4	1	2	1	4	----	----	----	----	----	----
	M	17–49	2	26	**32**	17	32	**48**	30	16	6	**22**	13	3	2
	M	67–98	2	6	16	14	**18**	9	4	2	----	----	----	----	----
	M	112	----	----	----	----	4	4	6	4	1	3	1	----	----
Mount Wilson	P	20–47	29	**40**	26	4	3	3	1	----	----	----	----	----	----
	P	85	7	**21**	12	1	----	----	----	----	----	----	----	----	----
	S	20–47	16	**34**	17	8	**14**	**15**	4	3	2	1	1	----	----
	S	85	----	10	**20**	5	6	----	----	----	----	----	----	----	----
	M	20–47	11	**29**	9	8	**19**	15	11	8	3	3	1	2	----
	M	85	----	5	**14**	6	7	2	----	----	----	----	----	----	----
Riverside	P	1–9	1	**14**	4	----	----	----	----	----	----	----	----	----	----
	P	44–85	18	**66**	45	17	16	7	1	----	----	----	----	----	----
	P	158	----	----	2	----	**9**	4	2	2	1	1	1	----	----
	S	1–9	3	**11**	**8**	3	**7**	3	4	----	----	----	----	----	----
	S	44–85	6	**38**	**38**	28	**36**	19	4	2	1	2	----	----	----
	S	158	----	----	----	1	**6**	4	4	2	4	----	----	----	----
	M	1–9	----	1	4	----	4	4	2	2	1	----	----	----	----
	M	44–85	5	**33**	**32**	16	**37**	25	9	2	----	3	----	----	----
	M	158	----	----	----	----	3	1	3	3	1	**6**	2	----	----
Santa Barbara	P	56	5	**17**	8	5	7	----	----	----	----	----	----	----	----
	P	145–176	----	7	**20**	**15**	**18**	8	5	----	----	----	----	----	----
	S	56	----	2	**17**	6	9	2	----	----	----	----	----	----	----
	S	145–176	----	1	7	6	**22**	**20**	10	4	3	2	----	----	----
	M	56	----	9	8	6	**12**	3	3	2	----	----	----	----	----
	M	145–176	2	2	3	6	**14**	**17**	**13**	7	2	1	----	----	----
La Jolla	P	162–195	----	5	**17**	5	9	5	3	----	----	----	----	----	----
	S	162–195	----	3	6	7	**13**	8	1	4	1	----	----	----	----
	All	1	4	**21**	11	6	4	----	----	----	----	----	----	----	----
	M	162–195	----	----	2	5	**11**	**12**	7	5	----	1	----	----	----

THE PERIODS RECORDED DURING MICROSEISMS

The measurements of the microseisms during the days which are listed in table 31 showed results which are listed in table 51. Again the same periods prevail as in earthquakes and blasts except that in this case the number of the longer periods is still more reduced than in the records of the blasts.

The records of the long-period instruments as Pasadena showed the following frequencies:

Periods in seconds	*Number*
0.1, 0.2	2
0.3	30
0.4	58
0.5	**189**
0.6	53
0.7–0.9	11
1.0–1.2	9
1.3–2.0	13
2.1–4.4	7
4.5–6.4	49
6.5–8.4	**125**
8.5–10	3

This tabulation shows again that periods of 0.4 to 0.6 second prevail by far. A second strong maximum occurs for periods between 6.5 and 8.5 seconds. The most remarkable result is that there are so few periods around 1 second recorded, although waves with this period are somewhat more frequently recorded by the short-period instruments at Pasadena (see table 51). It seems as if there are no vibrations with periods in the neighborhood of 1 second arriving in microseismic movements at the region near Pasadena.

TABLE 51.—*Microseisms*

NUMBERS OF OBSERVED PERIODS

Station	Periods in seconds											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
Pasadena, short period	1	32	**114**	48	**80**	49	30	8	6	**14**	10	4
Mount Wilson	67	**131**	50	17	4	----	----	----	----	----	----	----
Riverside	8	45	**162**	97	29	1	----	----	----	----	----	----
Santa Barbara	11	40	**26**	87	38	6	----	----	----	----	----	----
La Jolla	43	**109**	**179**	32	9	2	1	----	----	----	----	----
Tinemaha	3	97	**135**	59	39	16	9	4	----	3	----	----
Haiwee	9	22	**51**	40	**65**	44	22	9	7	3	2	1

PERCENTAGE OF OBSERVED PERIODS

Station	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
Pasadena, short period	0.3	8	**29**	12	**20**	12	7.5	2	1.5	3.5	2.5	1
Mount Wilson	25	**49**	18.5	6	1.5	----	----	----	----	----	----	----
Riverside	2	13	**47**	28	8.5	0.5	----	----	----	----	----	----
Santa Barbara	4	13	**41**	28	12	2	----	----	----	----	----	----
La Jolla	16	**40**	29	12	3	0.5	0.5	----	----	----	----	----
Tinemaha	1	27	**37**	16	11	4	2.5	1	----	1	----	----
Haiwee	3	8	**19**	15	**24**	16	8	3	2.5	1	0.5	0.5

THEORY

When an earthquake occurs, waves approaching more or less sinusoidal type with periods of between a very small fraction of 1 second and ½ minute or even more are produced. The very long waves, according to B. Gutenberg and C. F. Richter, apparently are connected with the movements of large blocks in the earth's crust. They do not depend to a noticeable extent on the depth of the focus, as earthquakes originating at the same place in regard to location as well as to depth in some cases show very long periods in all phases together with short periods and in other cases only short-period waves. In the first case there is usually some indication of block movement extending over a very much larger area than in the second case. The waves on their path very probably change their periods [2] due to the viscosity of the material in which they are propagated and to scattering. Another factor which may be involved is the different absorption of the energy for waves with different periods. It is a general belief that short waves undergo considerably stronger absorption than long waves, but it seems that this difference has been deduced merely from the observed fact that at large distances shorter earthquake waves disappear faster than long-period waves. Therefore, if one tries to explain the later fact by presuming larger absorption for the short-

[2] The word "period" in this section is defined as twice the time between 2 succeeding passings of the rest line regardless of the form of the wave.

period waves, a vicious circle may result. On the other hand, it seems very likely that the periods of all types of waves increase with distance due to the viscosity of the material in which they are propagated. The first theoretical investigations were published by K. Sezawa.[3] Sezawa developed his theory for certain cases of surface waves. In order to apply his formulas, the wave form must be known. Using some cases where single waves or half waves form the original disturbance, B. Gutenberg[4] found that in the case of the surface waves investigated by Sezawa a wave at the distance D from the source to a first approximation should have the period

$$T=\sqrt{T_0^2+\frac{aD}{V^3}}$$

where T is the period at the distance D, T_0 the period at the origin, V the velocity of the wave and a a constant depending on the viscosity of the material. This formula supposes a single wave and plane surface waves. The investigation of this problem has not been extended to body waves. On the other hand, it is not correct to use it in the case of a wave train. If, therefore, the given formula for T is applied to such cases, it is more or less an empirical formula. In the case of microseisms and surface waves, and in seismic field work where the periods are very much smaller than in earthquakes the change of periods with distance agrees very well with the formula. Besides, the coefficient of viscosity for the crustal part of the earth, which has been derived by using observed periods in earthquake surface waves, agrees well with values found in other ways.[5] The factor a in the latter investigation has been found to be about 1 for surface waves in earthquakes if all quantities are measured in seconds and kilometers.

Supposing that the formula is an approximation for body waves too, we find that it agrees fairly well with our observations of periods in the local shocks. There is some uncertainty as to what values should be used for the velocity, for the longitudinal as well as the transverse waves pass through layers where the velocity changes quite rapidly with depth. Assuming a velocity of longitudinal waves of 6 kilometers per second for short distances and of 8 kilometers per second for distances of 500 kilometers or more, we find that the periods of longitudinal waves should increase about in the following way if they are very short at the epicenter:

Distance in kilometers	50	100	500	1,000	2,000
Period in seconds	⅓	½	1	1½	2

In a similar way we find, theoretically, for transverse waves the following increase in period:

Distance in kilometers	50	100	500	1,000	2,000
Period in seconds	1	2	2½	3	5

The increase in period of the surface waves should be still faster.

The calculated results correspond well to the general trend of the observed periods in all three cases. The caculations indicate that a faster increase in period should be expected in the surface waves than

[3] K. Sezawa, On the decay of the waves in visco-elastic solid bodies (Bulletin of the Earthquake Research Institute, Tokyo, vol. III, 43, 1927).

[4] B. Gutenberg, Handbuch der Geophysik, vol. IV, p. 22.

[5] B. Gutenberg and H. Schlechtweg, Viskosität und innere Reibung fester Körper (Physikalische Zeitschrift, vol. 31, 1930, p. 745).

in the transverse waves and in the transverse waves than in the longitudinal waves. Both conclusions correspond to the observed facts. The increase in period seems to be slightly smaller than it has been calculated. Better agreement between observations and calculations may be found by using a slightly smaller value of a. The problem of increase in period at still greater distances needs further investigation.

The striking difference between the observations and the calculations is the fact that the theoretical method gives a gradual increase in period with distance, while the observations very clearly show abrupt changes in period at certain distances. If we plot the observed and the calculated curves, we find that the observed values give a step-like curve for which the calculated curve is a continuous approximation. The simplest explanation for this observed phenomenon may be that the ground vibrates mainly with the free vibration or its harmonic which is closest to the forced vibration given by the theory. It is very difficult to explain theoretically these free vibrations, as there are different possibilities not only due to the various harmonics of free vibration which may be observed but also due to the mode of vibration. Some theoretical investigations on free vibrations of the ground under different assumptions have been published by Sezawa and others. (See references on p. 163.) If we have free vibrations of the surface of a pendulum-like type, the relation between the free period and the thickness d of the layer vibrating in this way is very complicated and depends on the vibrating mass; the period is proportional to the square root of d. If we have free vibrations of a pipe-organ type, the observed wave lengths should be $\frac{1}{4}$, $\frac{3}{4}$, $\frac{5}{4}$ and so on of the thickness of the vibrating layer and, consequently, the periods should be proportional to d. In a homogeneous crust no free periods should be observable.

Considering the difficulties just mentioned we will make no attempt to calculate thicknesses of layers which correspond to the observed vibrations or to correlate them with the thickness of the layers which have been found in the region under investigation. Considering the relatively large number of known layers and the possibility of using harmonics of different order, it is not difficult to find such correlations, but there is always a good chance for misinterpretation of such results, the physical meaning of which is at least very doubtful.

According to the theory of Dr. H. Benioff, the strain seismograph should respond to free pendular vibrations of the ground only if the crustal block on which the instrument records is not a part of the system in free vibration. The records of the short-period strain seismograph at Pasadena show in all cases the same periods prevailing as on the other instruments:

TABLE 52.—*Relative frequencies, in percent, of periods under 1.5 seconds recorded on the short-period strain seismograph at Pasadena*

Phase	Periods in seconds											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1 to 1.2	1.3 to 1.4
P	3	**16**	9	4	**16**	**18**	8	3	1	4	5	3
S	2	8	4	6	**13**	**15**	7	5	4	4	6	6
M	1	**7**	1	1	4	**7**	5	6	9	**17**	10	6

The long-period strain seismograph records show less clearly the periods prevailing than do the records of other long-period instruments. In the P-phase about 20 percent of the recorded periods have values of about 1.5 seconds, while periods of 0.5 second are almost missing. In the S-phase more than one-third of all waves measured on the long-period strain records have periods between 4 and 8 seconds, and in the M-phase the proportion is still higher.

CONCLUSIONS

If an earthquake occurs, waves are produced at the epicenter showing certain "periods." These periods are mostly rather short, only a very small fraction of a second, but long periods occur too, especially in strong shocks. The larger the parts of the earth's crust are, which are affected by the earthquake, the longer the periods which occur together with short-period vibrations. Usually the largest acceleration occurs in waves having periods less than 0.5 second, while the largest displacement is very often observed in waves with periods over 1 second. In rare cases periods as long as 0.5 minute may occur in the epicentral region.

The effect of the structure at the epicenter on the periods seems, in general, to be small.

During their propagation the waves get longer and longer. Apparently to a first approximation the period is proportional to $\sqrt{\frac{D}{V^3}}$, where D is the distance in kilometers from the epicenter and V is the velocity in kilometers per second of the wave under consideration. The periods therefore increase with distance faster in waves with small velocities than in those with high velocities, faster for the maxima than for the S-phase and faster for the S-phase than for the P-phase. These results are not valid for the body waves at distances greater than 2,000 kilometers.

The theory of wave propagation in a homogeneous layer indicates a gradual change in period with distance. The studies show clearly that all observations in southern California are in agreement with observations in the other regions which have been discussed in the first section of this paper: Certain periods prevail and these dominant periods do not increase gradually with increasing distance but in jumps. The most probable explanation for this result is the assumption that the crust is layered and that we observe in most cases free oscillations of the ground. The periods in the observed movements in earthquakes as well as in blasts and microseisms show clearly a predominance of certain values. In southern California at each station there is an individual period between 0.1 and 0.4 second which occurs very much more frequently than others in this range of periods, as may be seen from the following tabulation:

TABLE 53.—*Dominant periods observed at the various stations for local earthquakes, blasts, and microseisms*

Station	Earthquakes less than 100 km away			Blasts less than 100 km away			Micro-seisms
	P	*S*	*M*	*P*	*S*	*M*	
Pasadena, short	0. 2–0. 3	0. 3	0. 2, 0. 5–0. 6	0. 2–0. 3	0. 3	0. 3	0. 3
Mount Wilson	0. 2	0. 2–0. 3	0. 2–0. 3	0. 2	0. 2–0. 3	0. 2–0. 3, 0. 5	0. 2
Riverside	0. 1	0. 1–0. 3	0. 1–0. 2	0. 2	0. 2–0. 3	0. 2–0. 3	0. 3
La Jolla	0. 2–0. 3	0. 3	0. 2–0. 4	----------	0. 2	----------	0. 2
Santa Barbara	0. 2	0. 2, 0. 3, 0. 5	0.2,0.6,0. 9–1. 0	0. 2	0. 3	(0. 2–0. 3)	0. 3
Tinemaha	0. 2–0. 3	0. 5	0. 5–0. 6	----------	----------	----------	0. 3
Haiwee	0. 2	0. 2–0. 3	0. 3, 0. 5	----------	----------	----------	0. 3

NOTE.—P=longitudinal wave, S=transverse wave, M=surface wave. In the neighborhood of the epicenter it is very difficult to discriminate between S and M, which usually together are responsible for most of the damage. Both phases consist mainly of vibrations perpendicular to the wave path.

At all our stations periods of 0.5 to 0.6 and of 1.0 to 1.1 seconds are observed very much more frequently than other periods near those values. The periods around 1 second occur infrequently as a rule at distances close to the epicenter, but it is not impossible that in very strong shocks these periods, too, may play an important role at short distances.

The dominant periods of less than 1 second are more outstanding in the vertical than in the horizontal components.